VIKING LABORATORIES INC.
6C107

INSTRUCTION MANUAL

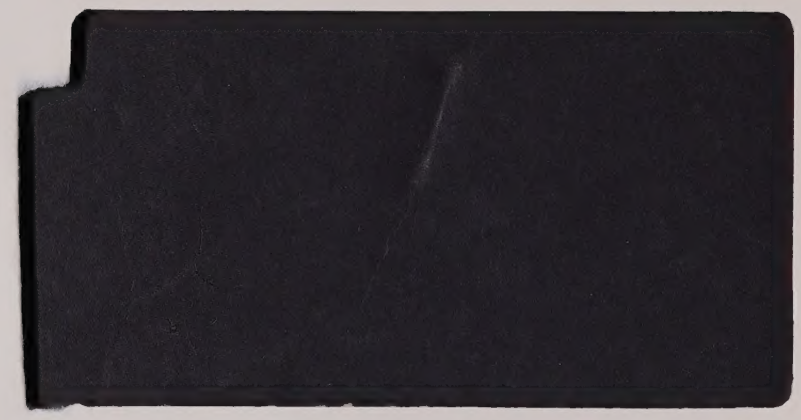
Sensitive Research*

AUTO-BALANCE AC-DC

TRANSFER STANDARD

MODEL ATS

SINGER
INSTRUMENTATION



INSTRUCTION MANUAL

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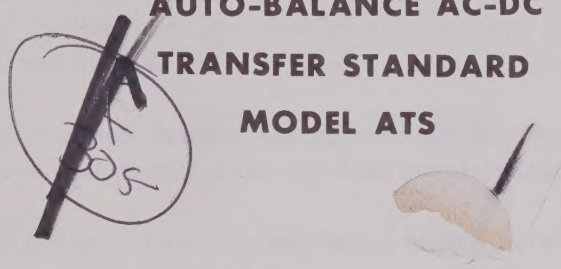

Serial No. _____

Instruction Manual No. 110-5081

SINGER
INSTRUMENTATION

Precision electrical and electronic instruments for measurement

emc — EMPIRE* — Gertsch* — Panoramic* — Sensitive Research*

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3. Description of trouble(2)
4. Test instruments used
5. Approximate date instrument was placed in operation
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7. Has maintenance action been previously requested?
8. Other comments

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(2) Include data on symptoms, measurements taken, suspected location of trouble, maintenance action taken, and any other relevant data.

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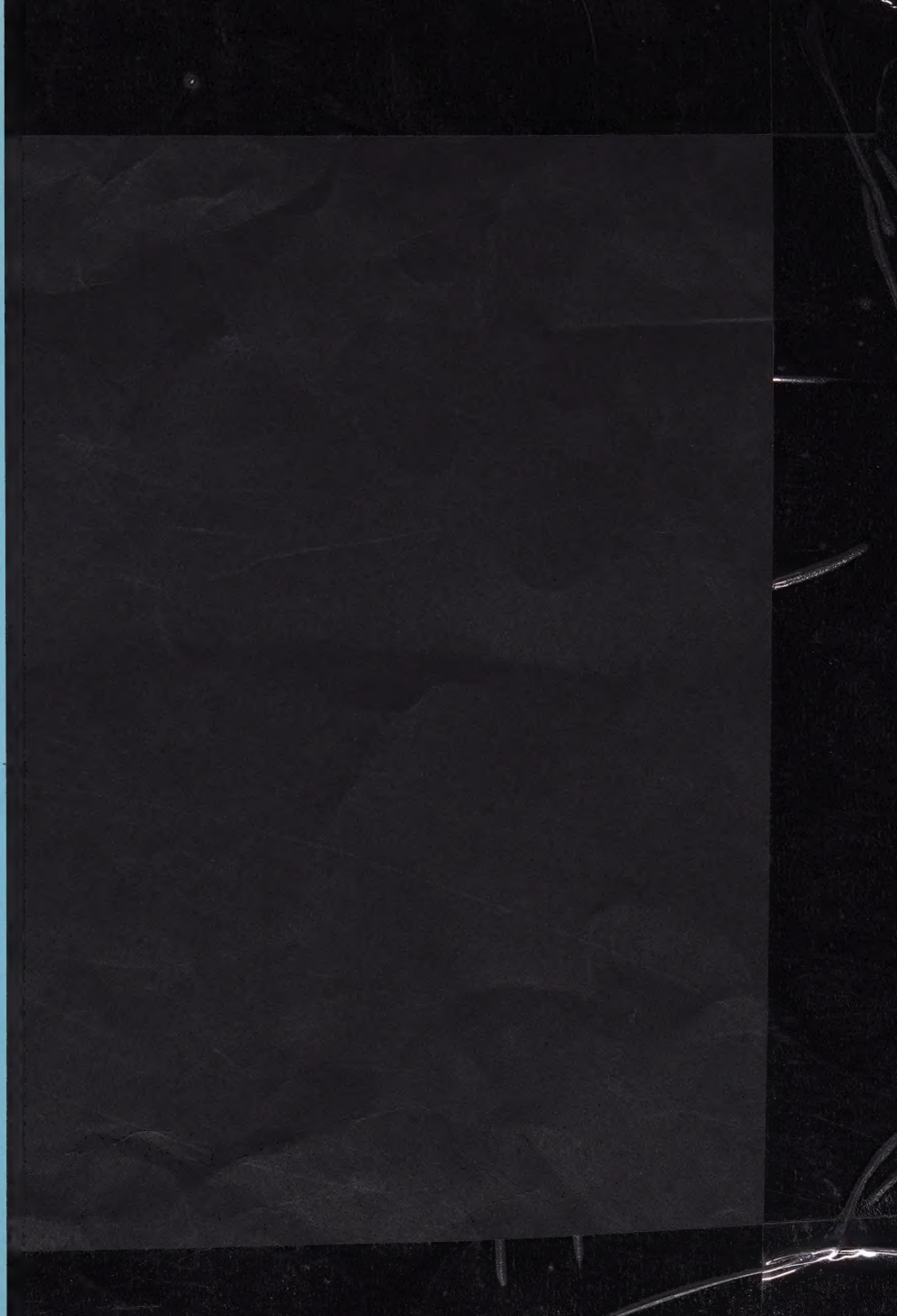

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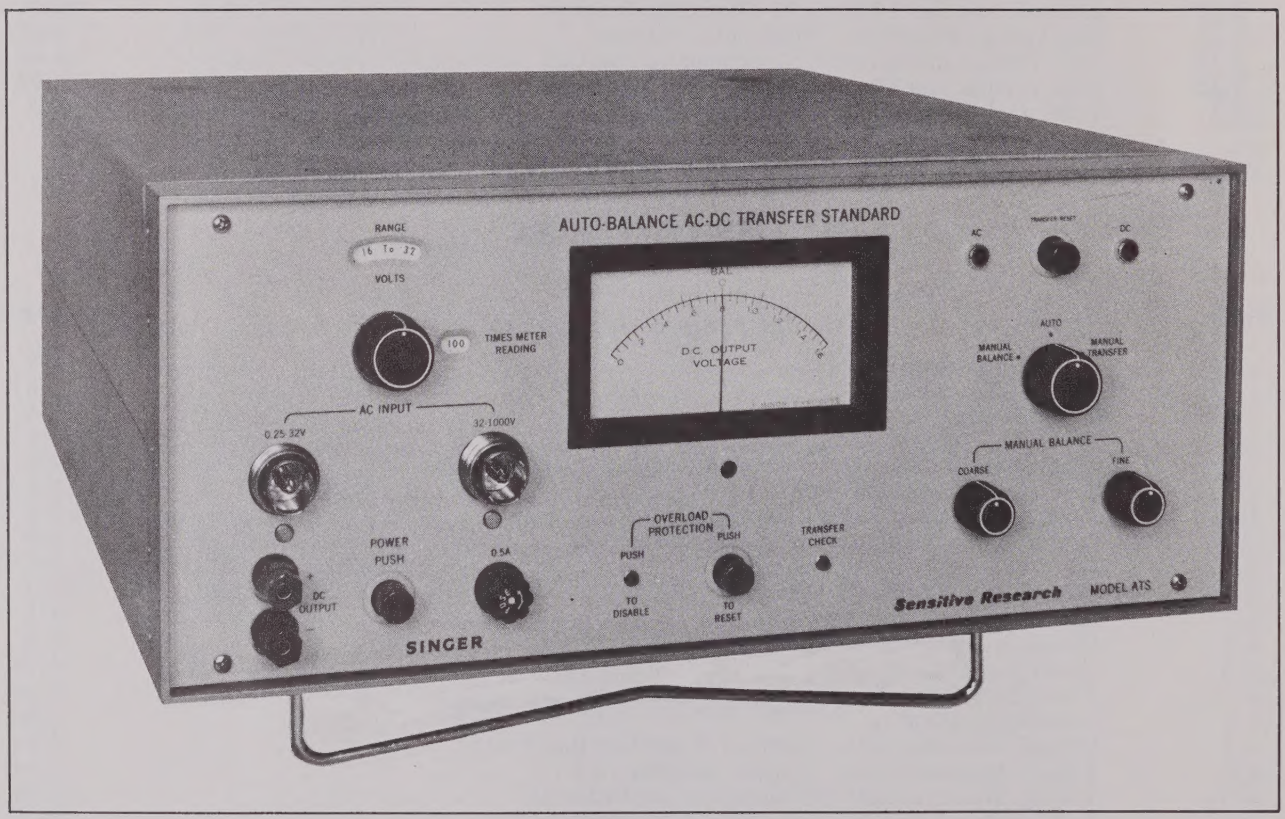

Figure 1-1. Model ATS Auto-Balance AC-DC Transfer Standard

SECTION I
INTRODUCTION

1-1. GENERAL.

1-2. This instruction manual provides operating and maintenance instructions for the SENSITIVE RESEARCH* Model ATS Auto-Balance AC-DC Transfer Standard (hereafter referred to as the ATS), manufactured by The Singer Company - Metrics Division. Included in this manual are a general description of the ATS, operating instructions, theory of operation, maintenance instructions, schematic diagrams and a repair parts list. The ATS is illustrated in figure 1-1.

1-3. The information contained in this manual refers to the standard version of the ATS and is current only to the date of publication. Differences in equipment components, specifications and performance resulting from The Singer Company's continuous product improvement program or customer design and application requirements are described in addendum sheets.

1-4. PURPOSE AND USE OF THE EQUIPMENT.

1-5. The ATS is designed to permit a semi-skilled operator to make rapid and precise true rms measurements of a-c voltages with a minimum of operator participation, thereby eliminating the possibility of operator error. The ATS also has the ability to provide manual transfer and balancing measurements (i.e., orthodox AC-DC transfer standard operation). The applied signal under measurement is attenuated and applied to a thermoelement which produces a d-c voltage proportional to the heating (rms) value of the signal. An internally generated d-c voltage having the same heating value is then substituted for the applied signal and this d-c voltage is coupled to auxiliary readout instrumentation to provide a true rms equivalent of the applied signal. The manual transfer mode of operation allows the operator to initiate the point in time at which the AC to DC transfer occurs and, in some instances, allows more accurate measurements than is possible in the automatic mode. The manual balance mode requires the operator to manually balance the unit and, while being somewhat more time-consuming, it is still a rapid operation and permits highest accuracy measurements down to 2 Hz.

1-6. GENERAL DESCRIPTION.

1-7. The ATS is a semi-automatic AC-DC transfer standard which provides a d-c output voltage equal to the true rms value of complex (i.e., pulsed, square-wave, triangular-wave and other non-sinusoidal signals having a crest factor of up to 10:1) or sinusoidal signals. The d-c output voltage generated is applied to an auxiliary readout instrument, such as a d-c differential or d-c digital voltmeter, which indicates the d-c rms equivalent of the applied voltage.

1-8. The ATS employs the same thermoelement and coaxial attenuators for sensing both the applied a-c signal and the internally-developed balancing voltage, thereby eliminating problems due to mismatch. Both the attenuators and the thermally-lagged thermoelement are housed in compartments of an easily removable transfer assembly (Model ATS-TA -- see figure 1-2). Removal of the transfer assembly permits its use as a conventional AC-DC transfer standard and also permits its shipment to NBS for reports on AC-DC differences with an uncertainty of less than 0.005% (to 20 kHz) and 0.01% (up to 50 kHz).

1-9. The ATS employs a positive-action peak-sensing overload system that does not clip the input signal. This feature eliminates the possibility of erroneous measurements due to undetected clipping or shunting of the applied signal. A non-locking pushbutton switch is provided to permit removal of the overload protection capability when measuring signals having a crest factor greater than 2:1.

1-10. A 12-position range selector switch, in conjunction with the internal attenuators, enables the measurement of input voltage levels from 0.25 to 1000 volts. Since the thermoelement has a square-law response, the range selection technique employed ensures that the equipment will not balance when the thermoelement driving current falls below approximately one-half the rated level of 5 milliamperes. This design consideration assures good signal-to-noise ratios for all measurements.

1-11. When the ATS is operating in the automatic transfer mode, special circuitry prevents automatic transfer until the thermoelement emf output rate of change is 0.002%/second or less. This ensures against inaccurate measurements resulting from the thermoelement's not having reached equilibrium. A normal transfer is accomplished in typically 10 seconds; however, when there is a large change in heater current, the time required for the thermoelement to reach a stable balance is extended resulting in a somewhat longer measurement time. When the ATS is operated in the manual transfer mode, the instant of transfer is manually determined. In manually-balanced operation, the operator adjusts the level of the internal balancing voltage until a null indication is obtained and then achieves transfer by manual switching.

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Figure 1-2. Model ATS-TA Transfer Assembly

1-12. ACCESSORIES.

1-13. The supplied and optionally available accessories are listed in tables 1-1 and 1-2, respectively.

1-14. EQUIPMENT SPECIFICATIONS.

1-15. The electrical and physical specifications of the ATS are listed in tables 1-3 and 1-4.

1-16. ASSEMBLY AND COMPONENT BOARD REFERENCE SYMBOL NUMBERS.

1-17. Table 1-5 lists reference symbol numbers of the assemblies and component boards contained in the ATS.

1-18. SEMICONDUCTOR, FUSE AND INDICATOR LAMP COMPLEMENT.

1-19. Table 1-6 lists the type and function of the entire complement of semiconductor devices employed in the ATS. The type and function of the fuses and indicator lamps employed in the equipment is listed in table 1-7.

TABLE 1-1. SUPPLIED ACCESSORIES

Accessory	Singer Part No.	Function
Card Extender	102-0120-001	Extends printed circuit card above chassis for ease of adjustment (stored inside main frame)
Coaxial Cable Connector	556147-128	Connects signal to AC INPUT connector

TABLE 1-2. OPTIONAL ACCESSORIES

Accessory	Singer Part No.	Function
Rack Mount Adaptors	102-0116-001	Enables ATS to be mounted in standard 19-inch rack
Rack Mount Adaptors and Slides	102-0118-001	Enables ATS to be slide-mounted in standard 19-inch rack
"T" Connector	556147-126	Permits monitoring of applied signal by auxiliary equipment
7-Pin Connector (Plug)	556147-186	Used to connect external programming cable to ATS
24-Pin Connector (Plug)	556147-108	Used when ATS-TA Transfer Assembly is operated independently of main frame
3-Pin Connector (Plug)	556016-074	Used when ATS-TA Transfer Assembly is operated independently of main frame

TABLE 1-3. SPECIFICATIONS

Parameter	Specification
Input voltage range	0.25-0.5/1/2/4/8/16/32/64/125/250/500/1000 volts
Frequency	D-C and 2 Hz to 30 MHz
Accuracy:	
Manual Mode	See Table 1-4
Auto and Manual transfer mode	0.005% of range additional to manual mode accuracy
Balance time (auto balance modes)	10 to 15 seconds typical (contingent on thermocouple time constant)
D-c output	Equal to rms value of input voltage (0.25 to 1000 volts @ up to 2 ma)
Output resistance	0.1 ohm to 10 volts
	1.0 ohm to 100 volts
	10 ohms to 1000 volts
Output stability	0.002% short term @ constant temperature
D-c output ripple and noise (rms)	90 dB below full scale or 100 μv, whichever is greater
D-c search meter accuracy	$\pm$ 5% (0-1.6 scale with front panel multiplier indicator)
Null resolution-manual mode	0.005% minimum per minor scale division for 5 divisions either side of zero. Resolution decreases thereafter

(cont'd)

TABLE 1-3. SPECIFICATIONS (Cont'd)

Parameter	Specification
Overload protection	Peak-sensing circuit trips at approximately 125% of selected range for sinusoidal input signals. Protects each range to 1000% overload or 1500 volts, whichever is less **Note** Overload protection circuit can be completely removed from measuring circuitry by means of PUSH TO DISABLE switch. This feature permits AC-DC transfer measurements in strict accordance with NBS practice.
Crest factor	2:1 in normal mode. Greater than 10:1 with overload protection circuitry disabled
Remote operation	Rear connections permit remote programming of AC-DC transfer by external contact closure
Power requirements	115 or 230 vac (switch selectable), 50 or 60 Hz, 0.45 amperes @ 115 v
Warmup time	Negligible (20 minutes to obtain maximum accuracy)
Operating temperature	+10° to +40° C
Size	17" wide x 17" deep x 7" high
Weight	40 lbs net; 56 lbs shipping

TABLE 1-4. ACCURACY-MANUAL MODE

Voltage Range	Frequency Range	AC-DC Difference % of Reading (See Note 1)
.25 to 1000 volts	5 Hz to 20 kHz 2 Hz to 5 Hz	0.01 0.1
.25 to 500 volts	20 kHz to 50 kHz	0.01
500 to 1000 volts	20 kHz to 50 kHz	0.03
.25 to 250 volts	50 kHz to 100 kHz	0.05
.25 to 16 volts	50 kHz to 1 MHz	0.05
.25 to 8 volts	1 MHz to 10 MHz	1.0
.25 to 8 volts	10 MHz to 30 MHz	5.0 (See Note 2)

Notes 1. Accuracies are referenced to the mid-point of a General Radio T connector (optional accessory).

NBS Test Reports can be obtained on the Model ATS-TA Transfer Assembly with an uncertainty on AC-DC difference of less than 0.005% up to 20 kHz.

The Singer Company offers the reduced accuracy above in keeping with its policy of conservatism in accuracy claims and to allow for minor differences resulting from the electronic circuitry.

2. Correction data is available for the .25 to 8 volt ranges for accuracies of 1% at frequencies from 10 to 30 MHz. This data is obtainable at added cost of special calibration. Correspondence is invited regarding this frequency range.

TABLE 1-5. ASSEMBLY AND COMPONENT BOARD REFERENCE SYMBOL NUMBERS

Assembly or Component Board	Reference Symbol Number
Transfer Assembly (Model ATS-TA)	A1
Overload Protection Board	A1A1
Chopper Amplifier	A2
DC Amplifier	A3
Low Voltage Amplifier	A4
Ladder and Buffer Amplifier	A5
Counter	A6
Counter	A7
Clock Oscillator	A8
+ 15 Volt Supply	A9
- 15 Volt Supply	A10
Low-Voltage Supply	A11
High-Voltage Amplifier No. 1	A12
High-Voltage Amplifier No. 2	A13
Service Extender Board	A14

TABLE 1-6. SEMICONDUCTOR COMPLEMENT

Reference Designation	Type	Function
CR1	1N4002	Transient suppression diode
CR2 and CR3	1N251	Steering diodes
Q1	2N4921	Series Regulator
A1BR1	MDA952-2 (Motorola)	Full-wave bridge rectifier
A1CR1 thru CR6	1N4002	Steering diodes
A1CR7	1N4002	Transient suppression diode
A1A1CR1 and CR2	1N4009	Detector
A1A1CR3 thru CR5	1N251	Steering diodes
A1A1CR6	1N251	Gate protection diode
A1A1CR7	1N1786	Relay-division switch protection diode
A1A1Q1 and Q2	132-0316-001 (matched pair-Singer)	P/O Balanced preamplifier
A1A1Q3 and Q4	2N3904	P/O Balanced preamplifier
A1A1Q5 and Q6	2N3904	Comparator

(Cont'd)

TABLE 1-6. SEMICONDUCTOR COMPLEMENT (Cont'd)

Reference Designation	Type	Function
A1A1Q7	2N3906	Overload control switch
A1A1Q8	2N2323	Overload control gated diode
A1A1Q9	2N1711	Relay control switch
A1A1Q10 and Q11	2N3904	Inverting Amplifier
A2Q1 and Q2	2N3391A	Low-noise amplifier
A2Q3	2N3391A	Emitter follower
A2Q4 and Q5	2N1306	Demodulators
A3CR1 thru CR4	1N251	Protection diodes
A3CR5 and CR6	1N751	Meter null sensitivity control
A3MC1 and MC2	μA709C (Fairchild)	Operational amplifiers
A4CR1 and CR2	1N751	Voltage reference
A4CR3 thru CR6	1N1703	Full-wave bridge rectifier
A4CR7	1N1786	Voltage regulator
A4Q1	2N3904	Amplifier
A4Q2	2N3906	Amplifier
A4Q3 and Q4	2N3904	Amplifiers
A4Q5	2N2323	Reset-control gated diode
A4Q6	2N4870	Delay generator
A4Q7 thru Q9	2N3904	Reset switches
A5MC1 thru MC3	MC889P (Motorola)	Inverter drivers for summing network
A5MC4	μA709C (Fairchild)	Operational amplifier
A5Q1	2N3904	Memory driver
A6MC1 thru MC8	MC892P (Motorola)	NAND gate counter-control logic
A6MC9 thru MC12	MC890P (Motorola)	Counter flip-flop
A7MC1 thru MC8	MC892P (Motorola)	NAND gate counter-control logic
A7MC9 thru MC12	MC890P (Motorola)	Counter flip-flop
A8MC1	MC888P (Motorola)	Up/down counter-control logic buffer

(Con'td)

TABLE 1-6. SEMICONDUCTOR COMPLEMENT (Cont'd)

Reference Designation	Type	Function
A8MC2	MC892P (Motorola)	Clock-output control logic buffer
A8MC3	MC825P (Motorola)	Clock-disable control logic
A8MC4	MC888P (Motorola)	Clock-disable control logic
A8Q1	2N3904	P/O Complementary error detector
A8Q2	2N3904	Inverter
A8Q3	2N3904	Clock gate
A8Q4	2N3904	Clock oscillator amplifier
A8Q5	2N3906	P/O Complementary error detector
A8Q6	2N1617A	Clock oscillator
A9CR1 and CR2	1N1703	Full-wave rectifiers
A9CR3	1N821	Voltage reference
A9CR4	1N751	Voltage regulator
A9Q1	2N3904	P/O Series regulator
A9Q2 and Q3	2N3904	Differential amplifier
A9Q4	40326 (RCA)	P/O Series regulator
A10CR1 and CR2	1N1703	Full-wave ac rectifiers
A10CR3	1N821	Voltage reference
A10CR4	1N751	Voltage regulator
A10Q1	2N3904	P/O Series regulator
A10Q2 and Q3	2N3904	Differential amplifier
A10Q4	40326 (RCA)	P/O Series regulator
A11CR1	1N823A	Voltage reference
A11CR2 and CR3	1N4002	P/O Full-wave bridge rectifiers
A11CR4 and CR5	1N4002	Buffer diodes
A11CR6 and CR7	1N4002	P/O Full-wave bridge rectifiers
A11MC1	μA709C (Fairchild)	Operational amplifier
A11Q1	40326 (RCA)	Series regulator (+3.9 VDC)
A11Q2	40326 (RCA)	P/O Series regulator

(Cont'd)

TABLE 1-6. SEMICONDUCTOR COMPLEMENT (Cont'd)

Reference Designation	Type	Function
A11Q3	2N3904	P/O Series regulator
A11Q4	2N3904	Error amplifier
A12CR1	1N251	Steering diode
A12Q1 thru Q7	40327 (RCA)	High-voltage output amplifier
A12Q8	2N3906	P/O High-voltage input amplifier
A12Q9	2N3904	P/O High-voltage input amplifier
A13CR1	1N969B	Voltage regulator for load-source current protection
A13CR2 thru CR5	HV-20B (Solitron)	Full-wave bridge rectifiers
A13Q1 thru Q7	40327 (RCA)	High-voltage output amplifier

TABLE 1-7. FUSE AND INDICATOR COMPLEMENT

Reference Designation	Type	Function
A1F1	313-3AG, 0.5 ampere delay type fuse	System protection
A1DS1 (P/O A1S1)	327	Power-on indicator
DS1	Leecraft No. 41EN-G5-2314	Indicates d-c output state
DS2	Leecraft No. 41EN-G5-2314	Indicates a-c balancing state
DS3 (P/O S2)	327	Indicates AC INPUT overload condition

SECTION II
OPERATION

2-1. GENERAL.

2-2. This section contains instructions for the installation and operation of the ATS. It is strongly recommended that the operator become thoroughly familiar with the material in this section before attempting to operate the equipment. Failure to do so may compromise the accuracy that has been engineered into the ATS.

2-3. INSTALLATION.

2-4. UNPACKING. Unpacking and handling of the ATS requires that the normal precautions and procedures applicable to the handling of sensitive electronic equipment be followed. The contents of all shipping containers should be checked against the packing slip to ascertain that the shipment is complete.

2-5. INSPECTION. After the ATS has been removed from its shipping container, visually inspect the equipment for indications of any damage that may have occurred during shipment. Check the front panel controls for freedom of movement, full travel and positive-detent locking. Note any evidence (such as broken glass, dents, etc.) indicating that the equipment has sustained a severe mechanical shock. To check that the ATS is operating properly, perform the Minimum Performance Standards Checks detailed in Section IV.

2-6. MOUNTING. The ATS is normally furnished for benchtop use. Optionally available accessories permit the equipment to be modified for rack mounting. (See figure 2-1 for equipment dimensions.)

2-7. Benchtop Mounting. Normal benchtop mounting of the ATS requires no special installation procedures. The equipment has four plastic feet that will not mar the work surface. A tilt-bar is provided on the underside of the equipment which, when extended provides a convenient angle for front panel viewing.

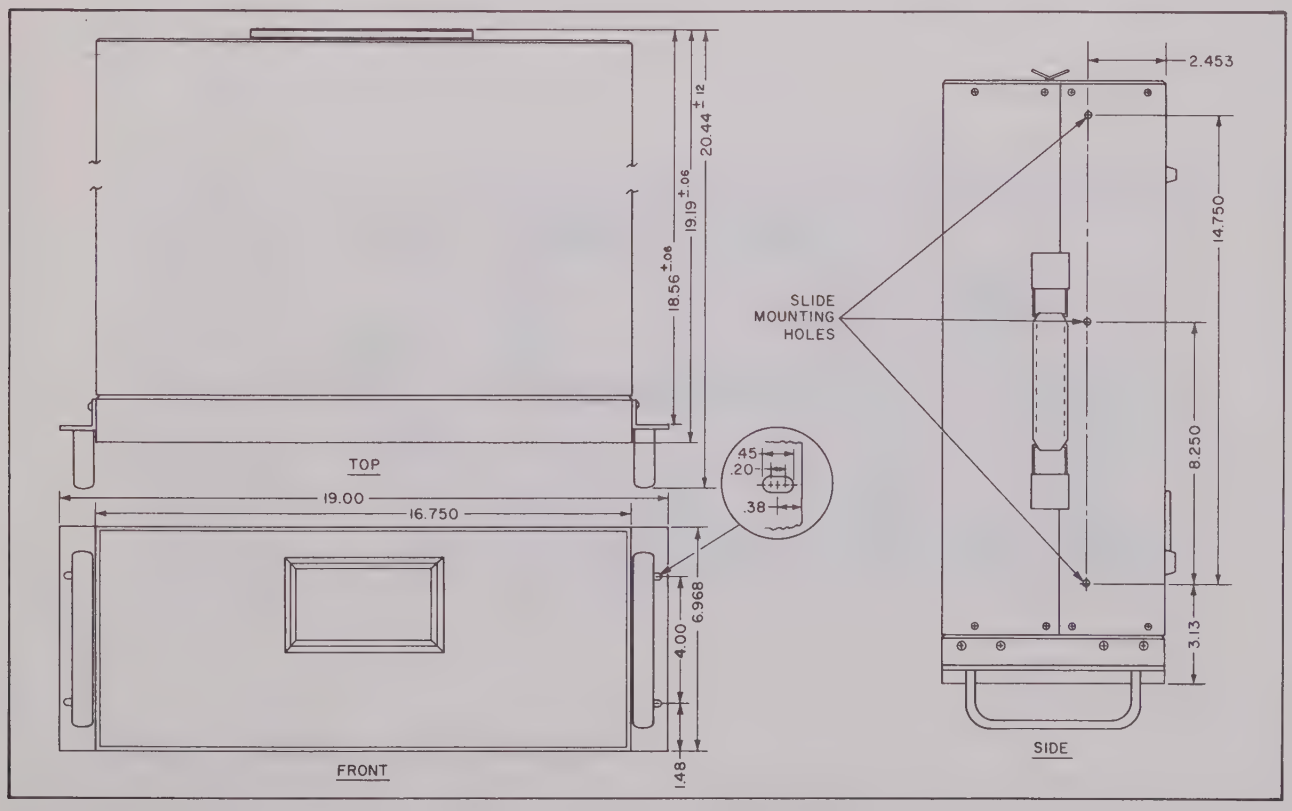


Figure 2-1. Installation Outline Drawing.

2-8. The 115V-230V slide switch at the rear of transfer assembly A1 should be set to the position corresponding to the available a-c line voltage. This switch is accessible from the rear panel of the ATS and can best be reached using a small-bladed screwdriver. When the switch is set to the left, the ATS is set for operation from a 115-volt line. Conversely, when the switch is set to the right, the equipment is set for 230-volt line operation. Once the switch has been properly set, couple the ATS to line power.

CAUTION

If the ATS has been adjusted to operate from a 230-volt line, replace the front panel fuse with a 0.25-ampere delay fuse rated at 230 volts and conspicuously tag the ATS to indicate that it has been adjusted for 230-volt operation.

2-9. Rack Mounting. If the ATS is to be rack-mounted, secure the rack mounting adaptors (Singer Part No. 102-0116-001) to the equipment using the eight supplied 10-32 x 3/8 bolts and washers. Once the adaptors have been secured, mount the ATS in a standard 19-inch rack using four 10-32 bolts. Be sure to set the 115V-230V slide switch as directed in paragraph 2-8 prior to installation in the rack.

2-10. If the ATS is to be mounted on rack slides (Singer Part No. 102-0118-001), first secure the slides to the sides of the equipment using the six supplied 10-32 x 1/2 bolts. Set the 115V-230V switch as directed in paragraph 2-8 and then install the ATS into the rack using four 10-32 bolts.

2-11. OPERATION.

2-12. OPERATING CONTROLS, INDICATORS AND CONNECTORS. The controls, indicators and connectors required for operation of the ATS are illustrated in figure 2-2; their functions are described in table 2-1.

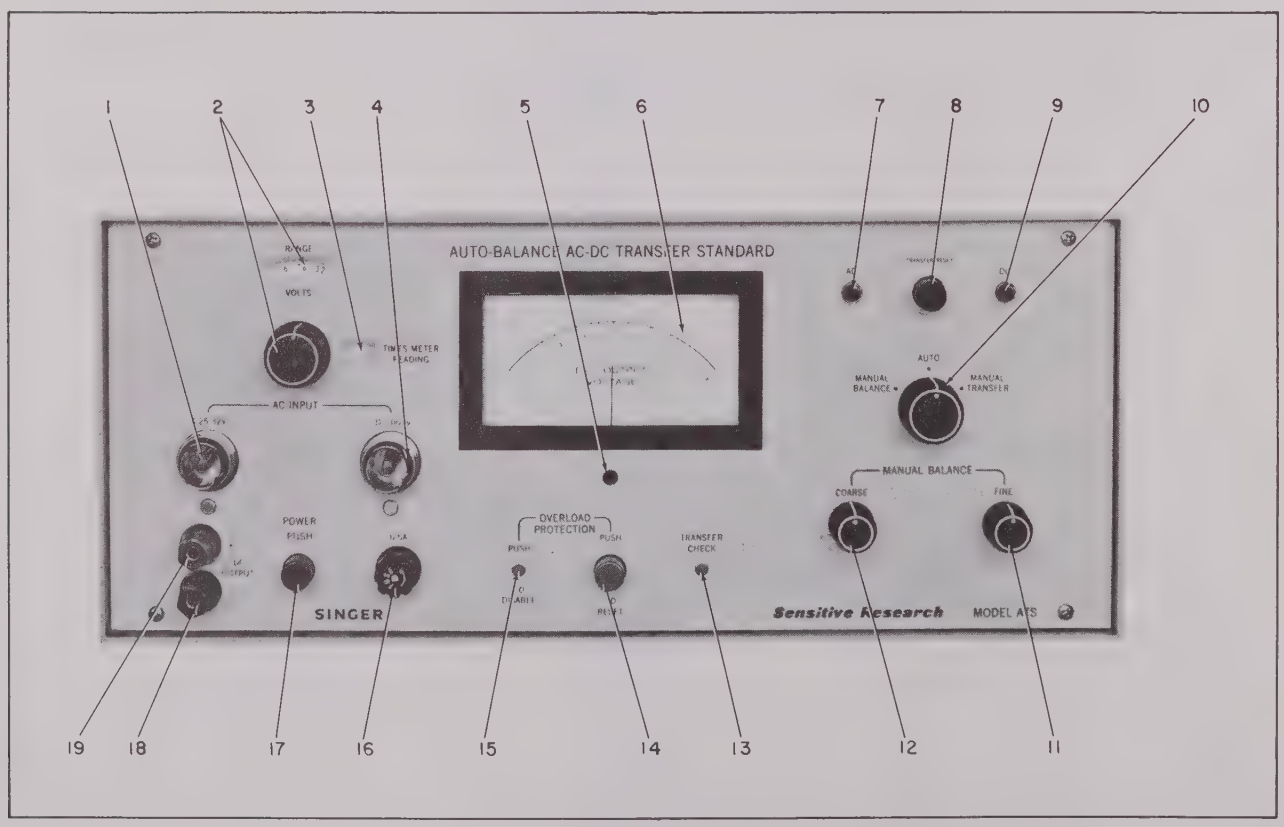


Figure 2-2. Operating Controls, Indicators and Connectors

TABLE 2-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS

Figure 2-2 Index No.	Control, Indicator or Connector	Function
1	AC INPUT 0.25-32V connector A1J4	Connector employed when RANGE VOLTS switch is set to measure applied voltages between 0.25 and 32 volts rms.
2	RANGE VOLTS switch A1S3 and dial	Permits operator to select any one of 12 voltage measurement ranges as indicated on dial 0.25 to 0.5 volts 0.5 to 1.0 volts 1 to 2 volts 2 to 4 volts 4 to 8 volts 8 to 16 volts 16 to 32 volts 32 to 64 volts 64 to 125 volts 125 to 250 volts 250 to 500 volts 500 to 1000 volts
3	TIMES METER READING dial	Provides factor which, when multiplied by the front panel meter DC OUTPUT VOLTAGE scale indication, enables the operator to determine (within 5%) the rms value of the applied signal after AC to DC transfer.
4	AC INPUT 32-1000V connector A1J6	Connector employed when RANGE VOLTS switch is set to measure applied voltages between 32 and 1000 volts rms.
5	Mechanical zero adjustment screw	Permits mechanical zero-setting of meter pointer.
6	Meter M1	Indicates proximity to null condition (0 on BAL scale) when AC indicator is illuminated and mode switch is set to MANUAL BALANCE, AUTO or MANUAL TRANSFER; indicates d-c output voltage (on DC OUTPUT VOLTAGE scale) within 5% when DC indicator is illuminated.
7	AC indicator DS1	Illuminates when ATS is in a-c balancing state (i.e., applied signal being automatically or manually nulled).
8	TRANSFER RESET switch S4	When mode switch is set to MANUAL BALANCE or MANUAL TRANSFER, permits the operator to switch between a-c balancing and d-c output states; when mode switch is set to AUTO, permits operator to recycle ATS for another measurement.
9	DC indicator DS2	Illuminates when ATS is in d-c output state (i.e., d-c equivalent of applied signal is being furnished at DC OUTPUT binding posts).
10	Mode switch S1	Permits operator to select operating mode: MANUAL BALANCE - operator must manually balance null meter before switching to d-c output state; AUTO - ATS automatically nulls and switches to d-c output state;

TABLE 2-1. OPERATING CONTROLS, INDICATORS AND CONNECTORS (Cont'd)

Figure 2-2 Index No.	Control, Indicator or Connector	Function
		MANUAL TRANSFER - ATS automatically nulls but operator must manually switch to d-c output state.
11	MANUAL BALANCE FINE control R2	Permits vernier adjustment of nulling voltage when operating in manual balance mode.
12	MANUAL BALANCE COARSE control R1	Permits coarse adjustment of nulling voltage when operating in manual balance mode.
13	TRANSFER CHECK switch S5	Provides a quick check for the nulling circuitry when ATS is in the d-c output state (i.e., DC indicator illuminated). Depression of the switch should cause the front panel meter to indicate nearness to null when in the d-c output state.
14	OVERLOAD PROTECTION PUSH TO RESET pushbutton switch/indicator S2/DS3	Illuminates when an overload has occurred. Momentary depression of the switch resets the overload protection circuitry. Note that if the overload remains or the indicator lamp within the switch fails, the circuitry cannot be reset.
15	OVERLOAD PROTECTION PUSH TO DISABLE pushbutton switch S3	When held depressed, disables the overload protection capability. This feature permits the measurement of a-c signals having a crest factor of up to 10:1.
16	0.5A fuseholder A1XF1	Houses line fuse.
17	POWER PUSH pushbutton switch/ indicator A1S1/A1DS1	Controls application of line power to ATS. When equipment is coupled to line power and switch is depressed, indicator will illuminate.
18	-DC OUTPUT binding post A1E2	Common (ground) d-c output terminal.
19	+DC OUTPUT binding post A1E1	Positive d-c output terminal.
Not shown	115V-230V switch A1S2.	Enables ATS to operate from either a 115-volt or 230-volt a-c line.
Not shown	Remote programming connector J14	Permits operation of the ATS (in automatic mode) from a remote location.

2-13. GENERAL INFORMATION. Although the ATS is a relatively simple instrument to use, the operator should read paragraphs 2-14 through 2-21 for the background material required to obtain maximum service from the equipment.

2-14. Setting RANGE VOLTS Switch. If the voltage range of the applied signal is known, the operator need only set the RANGE VOLTS switch to the appropriate position and couple the voltage to be measured to either the AC INPUT 0.25-32V or AC INPUT 32-1000V connector, as required. Should the signal be of unknown level, employ the conventional voltmeter technique of setting the RANGE VOLTS switch to the highest voltage range (500 TO 1000) and couple the signal to be measured to the AC INPUT 32-1000V connector. If balance cannot be achieved, the operator should increase the sensitivity of the ATS, switching input connectors when required, until a balance is achieved.

2-15. Signal Stability. The ATS is designed to measure the rms value of stable a-c voltages. Should the AC indicator light remain illuminated and/or the front panel meter continuously "hunts" or "slews" when the ATS is operated in either the automatic or manual transfer mode, it is likely that the applied signal is unstable. To judge the stability of the applied signal, the operator should switch to the manual balance mode and attempt to null the meter using the MANUAL BALANCE COARSE and/or FINE controls. If a balance condition cannot be maintained, the applied signal is fluctuating too rapidly to permit a measurement of specified accuracy to be made. Under these conditions the measurement should be made in the manual balance mode and the reduced accuracy

(due to the fluctuation of the signal) should be noted.

2-16. Sources of Error. Various sources of error may be present when employing the ATS. These sources are detailed below so that the user may be familiar with them and allow for them to obtain maximum accuracy.

a. Loading effects. The input impedance of the ATS, particularly on the low voltage ranges, is relatively low (due to the current required for the thermoelement heater) and will therefore have a loading effect when connected to the voltage source under test. Voltage sources having a non-zero output impedance and/or poor regulation characteristics will therefore develop two different output levels: one while the ATS is in the a-c balancing state (loading the source) and a second when the ATS is in the d-c transfer state (voltage source removed from ATS input attenuator). The output voltage of the ATS, as indicated on the readout instrument, will be the voltage of the loaded source.

b. Losses in interconnecting wiring. Since the ATS has an input impedance of approximately 200 ohms/volt, the voltage drop in the wiring interconnecting the voltage source and the ATS may introduce a measurement error, particularly when the low voltage ranges are employed. It is recommended that short heavy leads be employed when interconnecting the equipment.

c. Thermal emfs in d-c output system. Nonsimilar conductors employed to couple the DC OUTPUT binding posts to the readout instrument will introduce thermal emfs. It is recommended that conductors of the same material (copper) be employed.

d. Settling time. When the ATS transfers from the a-c balancing state to the d-c output state in the AUTO mode, the internal d-c substitution voltage builds up to balance that voltage stored in the digital memory circuit. The operator should allow approximately 10 seconds to elapse before reading the d-c output voltage.

e. Stability. Due to inherent temperature-dependent drift in the thermoelement output ($\approx 0.01\%$/minute after a 10-minute warmup), the ATS output voltage should be measured as soon as the instrument has settled in the d-c output mode. If a potentiometer system or differential voltmeter is employed as the readout instrument, balance the readout instrument as closely as possible after the ATS has transferred to the d-c output state. Repeat the measurement cycle a second time and then null the readout instrument. Note that, for maximum d-c output stability, the ATS should be allowed to warm up for at least 4 hours before measurements are made.

f. Attenuator heating. When measuring voltages between 250 and 1000 volts, the power dissipated by the input attenuators will produce a slight change in resistance. It is recommended that the MANUAL TRANSFER mode be employed when measuring such voltages and that transfer be made after the signal under measurement has been applied for approximately two minutes (thereby allowing the input attenuator resistance to stabilize).

g. Repeatability. Lack of perfect repeatability is due to internal noise, finite digital memory resolution, contact resistance in switches and relays, thermal effects on attenuators, etc. Since these error sources are random in nature, several measurements should be made and the results averaged to obtain ultimate accuracy.

2-17. Mode Selection. The ATS has three modes of operation, each selected by the setting of the front panel switch. When the switch is set to MANUAL BALANCE, the operator manually adjusts the MANUAL BALANCE COARSE and/or FINE controls until a null (0 on the meter BAL scale) is attained. After transfer, the voltage at the DC OUTPUT binding posts will be equal to the rms value of the applied a-c signal. While this mode of operation provides the greatest measurement accuracy (due to the finite resolution of the digital memory circuitry in the AUTO mode), it is slightly more time consuming -- although substantially faster than conventional AC-DC transfer standard measurements.

2-18. When the mode switch is set to AUTO or MANUAL TRANSFER, the ATS balances automatically. In the AUTO mode, AC to DC transfer is performed automatically while the AC to DC transfer in the MANUAL TRANSFER position of the switch is determined by the operator.

2-19. Voltmeter Operation. The ATS can be employed as a voltmeter to provide a relatively coarse indication of applied signal levels. When the instrument is operated in either the automatic or manual transfer mode, the d-c equivalent of the applied a-c signal rms level can be read by multiplying the meter DC OUTPUT VOLTAGE scale indication by the factor specified on the TIMES METER READING dial after transfer has been achieved. The voltage thus obtained will be within $\pm 5\%$ of the true input signal rms level.

2-20. Overload Protection. An overload protection capability is provided which will automatically remove the applied signal from the attenuator/thermoelement circuitry whenever the peak value of the applied signal exceeds 125% of the selected range high voltage limit. Thus, if the RANGE VOLTS switch is set to 125 to 250 and the peak value of the applied signal is in excess of 330 volts (although its rms value is between 125 and 250 volts), the overload protection circuitry will be triggered. The OVERLOAD PROTECTION PUSH TO RESET pushbutton switch/indicator will illuminate to indicate that an overload condition was and/or is present. The ATS will not be capable of measurement until the overload condition has been corrected (i.e., setting the RANGE VOLTS switch to a higher range and depressing the OVERLOAD PROTECTION PUSH TO RESET pushbutton switch/indicator).

2-21. The overload protection circuitry is normally not intentionally disabled unless signals having a high crest factor (greater than 2:1) are being measured. When such signals are applied to the ATS, the overload protection circuitry (if not disabled) would remove the signal although the signal rms value is less than 125% of the selected range high limit. Since the rms level of the applied signal will not damage either the attenuator or thermoelement, the overload protection circuitry may be disabled by holding the OVERLOAD PROTECTION PUSH TO DISABLE pushbutton switch depressed for the duration of the measurement.

EXAMPLE

Assume that the a-c signal to be measured has a peak value of 150 volts and a crest factor of 3:1. When the operator sets the RANGE VOLTS switch to 125 TO 230, the ATS will not be capable of providing a meter indication of 0 on the BAL scale since the rms value of the applied signal (50 volts) is below the selected measurement range.

When the operator switches to the next lower position of the RANGE VOLTS switch (i.e., 64 TO 125), the ATS will still not balance because the rms value of the applied signal is still below the selected measurement range. Note that the peak value of the applied signal is not greater than 125% of the selected range high voltage limit of 125 volts, hence the overload protection circuitry will not be triggered.

Since a null was not obtained, the operator now sets the RANGE VOLTS switch to 32 to 64. The peak value of the applied signal is now in excess of 125% of the selected range high voltage limit, causing the overload protection circuitry to trigger and remove the applied signal from attenuator network. The OVERLOAD PROTECTION PUSH TO RESET pushbutton switch/indicator will illuminate to indicate that an overload condition exists.

To measure the rms value of the applied signal, the operator should depress the OVERLOAD PROTECTION PUSH TO DISABLE switch and, while holding this switch depressed, momentarily depress the OVERLOAD PROTECTION PUSH TO RESET switch. The OVERLOAD PROTECTION PUSH TO RESET indicator will no longer be illuminated and the operator can perform the selected measurement. After transfer has been achieved, the operator should set the RANGE VOLTS switch to the next higher range and then release the OVERLOAD PROTECTION PUSH TO DISABLE pushbutton switch.

CAUTION

To prevent damage to the thermoelement, follow the above example whenever high crest factor signals are to be measured (i.e., null cannot be obtained on initial setting of the RANGE VOLTS switch).

It should be stressed that the overload protection circuitry is not designed to serve as a range indicator and that continuous overloading of the ATS may result in the eventual degradation of the thermoelement.

2-22. MANUAL BALANCE OPERATION. To operate the ATS in the manual balance mode, proceed as directed in the following steps.

a. Couple the ATS to line power and momentarily depress the POWER PUSH pushbutton switch; the indicator portion of the switch should illuminate. Allow the ATS to warm up for at least 20 minutes.

b. Set the mode switch to MANUAL BALANCE.

c. Set the RANGE VOLTS switch to obtain a dial indication of 500 to 1000.

d. Interconnect the equipment as illustrated in figure 2-3, coupling the voltage source under measurement to the AC INPUT 32-1000V connector.

e. Note which indicator (AC or DC) is illuminated. If the DC indicator is illuminated, momentarily depress the TRANSFER-RESET pushbutton switch; the AC indicator will become illuminated and the DC indicator will become extinguished.

f. Note if the OVERLOAD PROTECTION PUSH TO RESET indicator is illuminated. If it is, momentarily depress the OVERLOAD PROTECTION PUSH TO RESET pushbutton switch. The indicator should become extinguished.

g. Adjust the MANUAL BALANCE COARSE and/or FINE controls to obtain a meter indication of 0 on the BAL scale. When this indication is obtained, the ATS is ready to be set to the d-c output state.

Note

1. If it is not possible to obtain a meter indication of 0 on the BAL scale, the RANGE VOLTS switch is set to the wrong range. See the example following paragraph 2-21.

2. Transients developed when switching between RANGE VOLTS switch settings (particularly between the 16 TO 32 and 32 TO 64 positions) may cause the overload protection circuitry to trigger. If this occurs, momentarily depress the OVERLOAD PROTECTION PUSH TO RESET pushbutton switch.

WARNING

A substantial shock can occur if the operator inadvertently contacts the +DC OUTPUT and -DC OUTPUT binding posts when the DC indicator is illuminated.

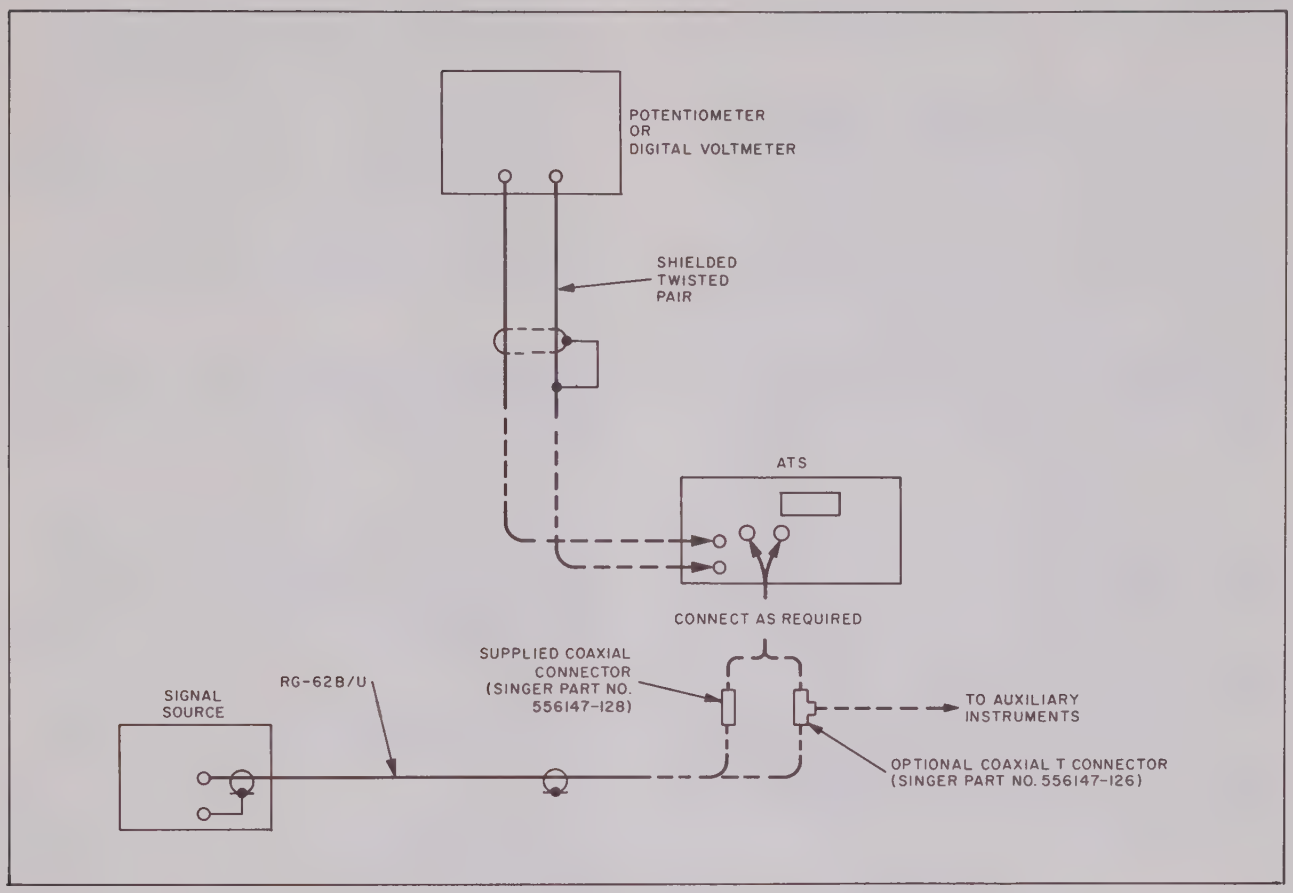


Figure 2-3. Equipment Interconnection Diagram

h. Momentarily depress the TRANSFER-RESET pushbutton switch to place the ATS in the d-c output state; the DC indicator should illuminate. A d-c output voltage equivalent to the rms value of the signal under measurement can be obtained from the indication of the digital vtvm or potentiometer connected between the +DC OUTPUT and -DC OUTPUT binding posts. Note that a less accurate reading can be obtained by noting the meter DC OUTPUT VOLTAGE scale indication and multiplying this value by the factor indicated in the TIMES METER READING dial.

i. To perform another measurement, repeat steps e through h.

2-23. REVERSE MANUAL BALANCE OPERATION. To operate the ATS in the reverse manual balance mode (i.e., using the ATS to provide a reference output level and then setting the rms value of the applied signal to equal this voltage), proceed as follows.

a. Couple the ATS to line power and momentarily depress the POWER PUSH pushbutton switch; the indicator portion of the switch should illuminate. Allow the ATS to warm up for at least 20 minutes.

b. Set the mode switch to MANUAL BALANCE.

WARNING

A substantial shock can occur if the operator inadvertently contacts the +DC OUTPUT and -DC OUTPUT binding posts when the DC indicator is illuminated.

c. Set the RANGE VOLTS switch to obtain the desired voltage and note which indicator (AC or DC) is illuminated. If the AC indicator is illuminated, momentarily depress the TRANSFER-RESET pushbutton switch; the AC indicator will become extinguished and the DC indicator will be illuminated.

d. With the voltage source set for minimum output level, interconnect the equipment as illustrated in figure 2-3.

e. Adjust the MANUAL BALANCE COARSE and/or FINE controls until the desired rms voltage level (as indicated on the d-c digital voltmeter or potentiometer) is obtained.

f. Without further adjustment of either the MANUAL BALANCE COARSE and/or FINE control, momentarily depress the TRANSFER-RESET pushbutton

switch; the DC indicator will become extinguished and the AC indication will be illuminated.

g. Carefully adjust the output level of the voltage source until the pointer of the ATS meter deflects to an indication of 0 on the BAL scale. When this occurs, the voltage source output level has been set to the desired value.

2-24. AUTOMATIC BALANCE OPERATION. To operate the ATS in the automatic balance mode, proceed as directed in the following steps.

a. Couple the ATS to line power and momentarily depress the POWER PUSH pushbutton switch; the indicator section of the switch should illuminate. Allow the ATS to warm up for at least 20 minutes.

b. Set the mode switch to AUTO; the AC indicator will become illuminated.

c. Set the RANGE VOLTS switch to obtain a dial indication of 500 TO 1000.

d. Interconnect the equipment as illustrated in figure 2-3, coupling the voltage source under measurement to the AC INPUT 32-1000V connector.

e. Note if the OVERLOAD PROTECTION PUSH TO RESET indicator is illuminated. If it is, momentarily depress the OVERLOAD PROTECTION PUSH TO RESET pushbutton switch. The indicator should become extinguished.

WARNING

A substantial shock can occur if the operator inadvertently contacts the +DC OUTPUT and -DC OUTPUT binding posts when the DC indicator is illuminated.

f. After approximately 10 seconds, the meter pointer will deflect to an indication of 0 on the BAL scale. At this time the AC indicator will be extinguished and the DC indicator will illuminate. A d-c output voltage equivalent to the rms value of the signal under measurement can be obtained from the indication of the d-c digital voltmeter or other readout instrument connected between the +DC OUTPUT and -DC OUTPUT binding posts. Note that a less accurate reading can be obtained by noting the meter DC OUTPUT VOLTAGE scale indication and multiplying this value by the factor indicated in the TIMES METER READING dial.

Notes

1. If it is not possible to obtain a meter indication of 0 on the BAL scale, the RANGE VOLTS switch is set to the wrong range. See the example following paragraph 2-21.

2. Transients developed when switching between RANGE VOLTS switch settings (particularly between the 16 TO 32 and 32 TO 64 positions) may cause the overload protection circuitry to trigger. If this occurs, momentarily depress the OVERLOAD PROTECTION PUSH TO RESET pushbutton switch.

i. To perform another measurement, momentarily depress the TRANSFER-RESET pushbutton switch.

2-25. MANUAL TRANSFER OPERATION. To operate the ATS in the manual transfer mode, proceed as directed in the following steps.

a. Couple the ATS to line power and momentarily depress the POWER PUSH pushbutton switch; the indicator section of the switch should illuminate. Allow the ATS to warm up for at least 20 minutes.

b. Set the RANGE VOLTS switch to 500 TO 1000.

c. Set the mode switch to MANUAL TRANSFER and note which indicator (AC or DC) is illuminated. If the DC indicator is illuminated, momentarily depress the TRANSFER-RESET pushbutton switch; the DC indicator will be extinguished and the AC indicator will illuminate.

d. Interconnect the equipment as illustrated in figure 2-3, coupling the voltage source under measurement to the AC INPUT 32-1000V connector.

e. Note if the OVERLOAD PROTECTION PUSH TO RESET indicator is illuminated. If it is, momentarily depress the OVERLOAD PROTECTION PUSH TO RESET pushbutton switch; the indicator section of the switch should be extinguished.

WARNING

A substantial shock can occur if the operator inadvertently contacts the +DC OUTPUT and -DC OUTPUT binding posts when the DC indicator is illuminated.

f. After approximately 10 seconds, the meter pointer will deflect to an indication of 0 on the BAL scale. When the pointer comes to rest within one-half division of 0, momentarily depress the TRANSFER-RESET pushbutton switch. At this time the AC indicator will be extinguished and the DC indicator will illuminate. A d-c output voltage equivalent to the rms value of the signal under measurement is available at the DC OUTPUT binding posts and can be read by means of the d-c digital voltmeter or potentiometer. Note that an approximate reading may be obtained by noting the meter DC OUTPUT scale indication and multiplying this value by the factor indicated in the TIMES METER READING dial; this feature permits presetting of differential voltmeter controls.

Notes

1. If it is not possible to obtain a meter indication of 0 on the BAL scale, the RANGE

VOLTS switch is set to the wrong range. See the example following paragraph 2-21.

2. Transients developed when switching between RANGE VOLTS switch settings (particularly between the 16 TO 32 and 32 TO 64 positions) may cause the overload protection circuitry to trigger. If this occurs, momentarily depress the OVERLOAD PROTECTION PUSH TO RESET pushbutton switch.

g. To perform another measurement, repeat steps c through f.

2-26. AUTOMATIC BALANCE OPERATION FROM A REMOTE LOCATION. To operate the ATS in the automatic balance mode from a remote location, proceed as directed in the following steps.

Note

This procedure assumes that the voltage under measurement does not require resetting of the RANGE VOLTS switch.

a. With the ATS removed from line power, remove the plastic plug cover that protects the rear panel multipin connector.

b. Remove the jumper between contacts D and E of the connector.

c. Fabricate a remote control box (see figure 2-4) and interconnect the ATS and remote control box as illustrated in figure 2-5.

d. Couple both the ATS and the remote control box to line power and energize the equipment.

e. Set the ATS mode switch to AUTO and the RANGE VOLTS switch to that range compatible with the signal to be measured.

f. Operate the ATS as in the standard automatic balance mode (refer to paragraph 2-26), using the pushbutton switch on the remote control box to switch between a-c balance and d-c output states. Note that range switching and resetting of the overload protection circuitry cannot be accomplished at the remote control box.

2-27. INDEPENDENT OPERATION OF TRANSFER ASSEMBLY A1. At times it may be required that the transfer assembly (Model ATS-TA) be operated independently of the remainder of the ATS system. Such instances occur when the transfer assembly is sent to the National Bureau of Standards for a test report on AC-DC difference. The wiring for independent operation of the transfer assembly is illustrated in figure 2-6. Note that the circuitry shown by heavy lines are the minimum required for independent operation.

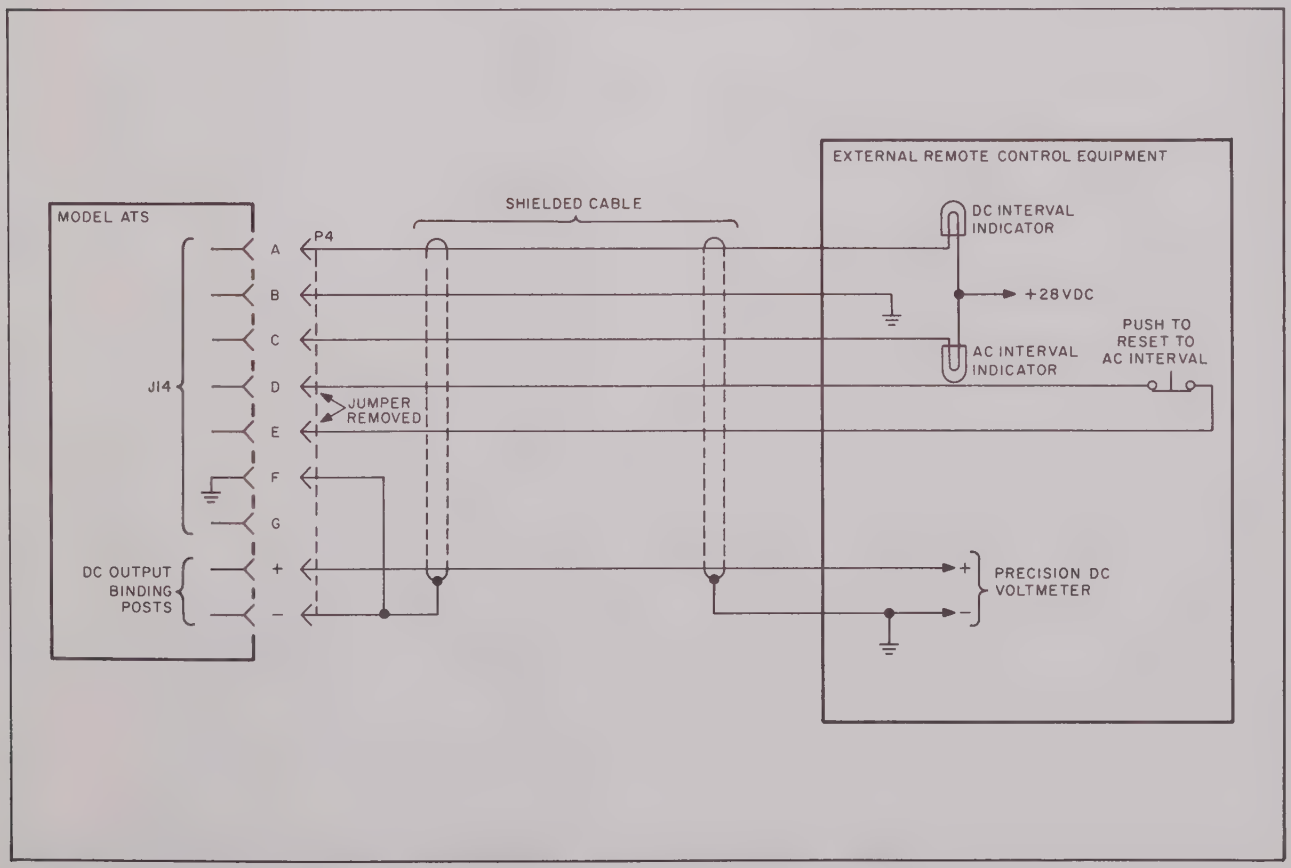


Figure 2-4. Typical Remote Control Box

CAUTION

If the transfer assembly is to be operated without the operation of the overload protection capability, care must be taken to ascertain that the voltage range setting of the RANGE VOLTS switch is compatible with the a-c voltage to be measured.

2-28. To remove the transfer assembly from the equipment frame, proceed as directed in the following steps.

a. With the ATS unenergized, remove the four screws (two on each side of the ATS near the front panel) that secures the top/side cover to the equipment frame.

b. Remove the four screws (two on each side of the ATS near the rear panel) and associated hardware that secures the top/side cover to the equipment frame.

c. Remove the top/side cover from the equipment frame.

d. Carefully turn the ATS upside-down and remove the eight screws that secure the bottom cover to the equipment frame. Note that two of these screws have associated washers and nuts.

e. Remove the bottom cover.

f. Disconnect the three multipin connectors from their mating receptacles on the transfer assembly.

g. Place the ATS on its left side.

h. Remove the four screws that secure the transfer assembly to the equipment frame.

i. Carefully place the ATS rightside-up.

j. Gently slide the transfer assembly toward the rear of the equipment and, using both hands, carefully lift the transfer assembly out of the equipment.

2-29. PACKAGING INSTRUCTIONS.

2-30. SHORT TERM STORAGE. If the ATS is to be stored for a short time, cover the equipment with suitable protective covering (such as a sheet of plastic or paper) and store the equipment in a clean and dry area that is not subject to extreme temperature variations.

2-31. LONG TERM STORAGE OR SHIPMENT. If the ATS is to be stored for a long period, or shipped, proceed as directed below.

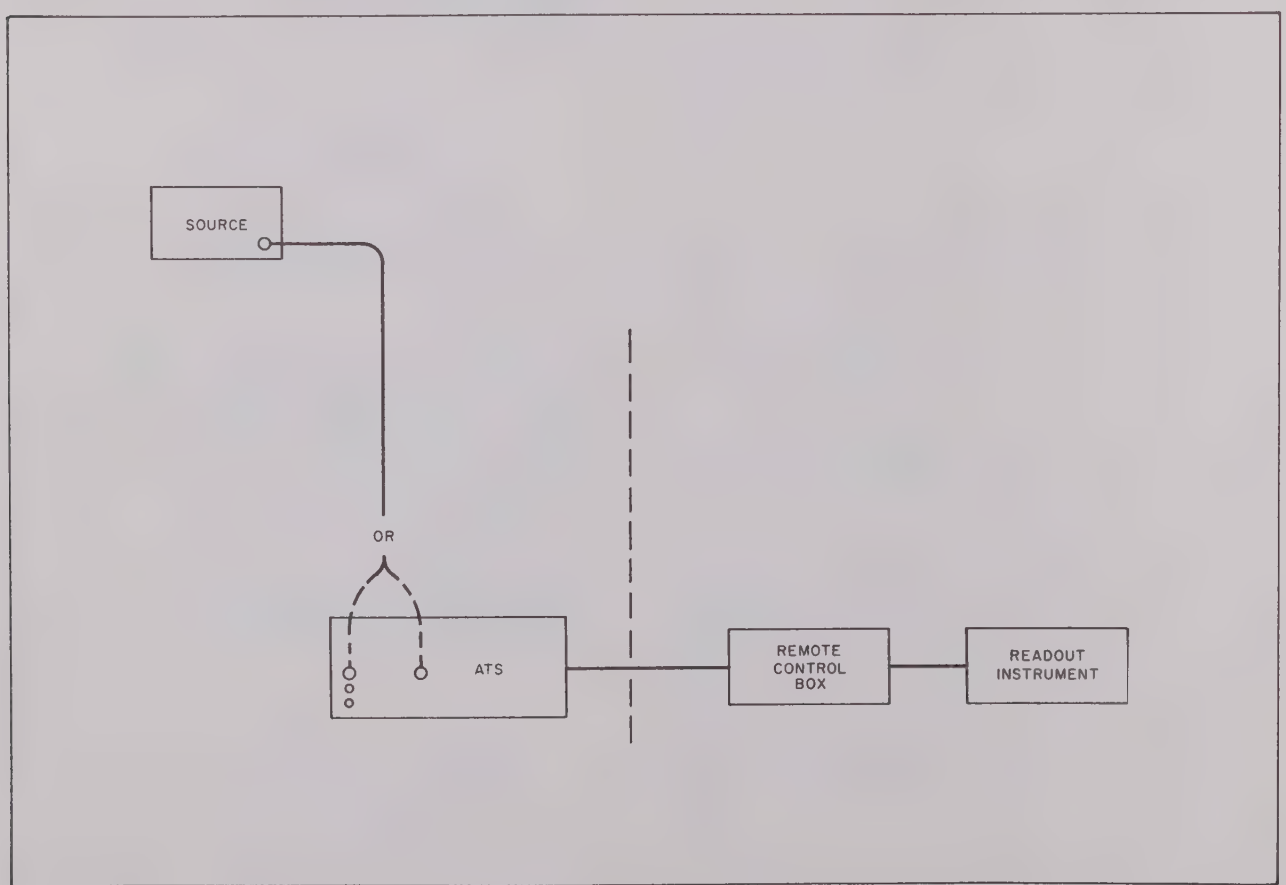


Figure 2-5. Equipment Interconnection for Remote Operation

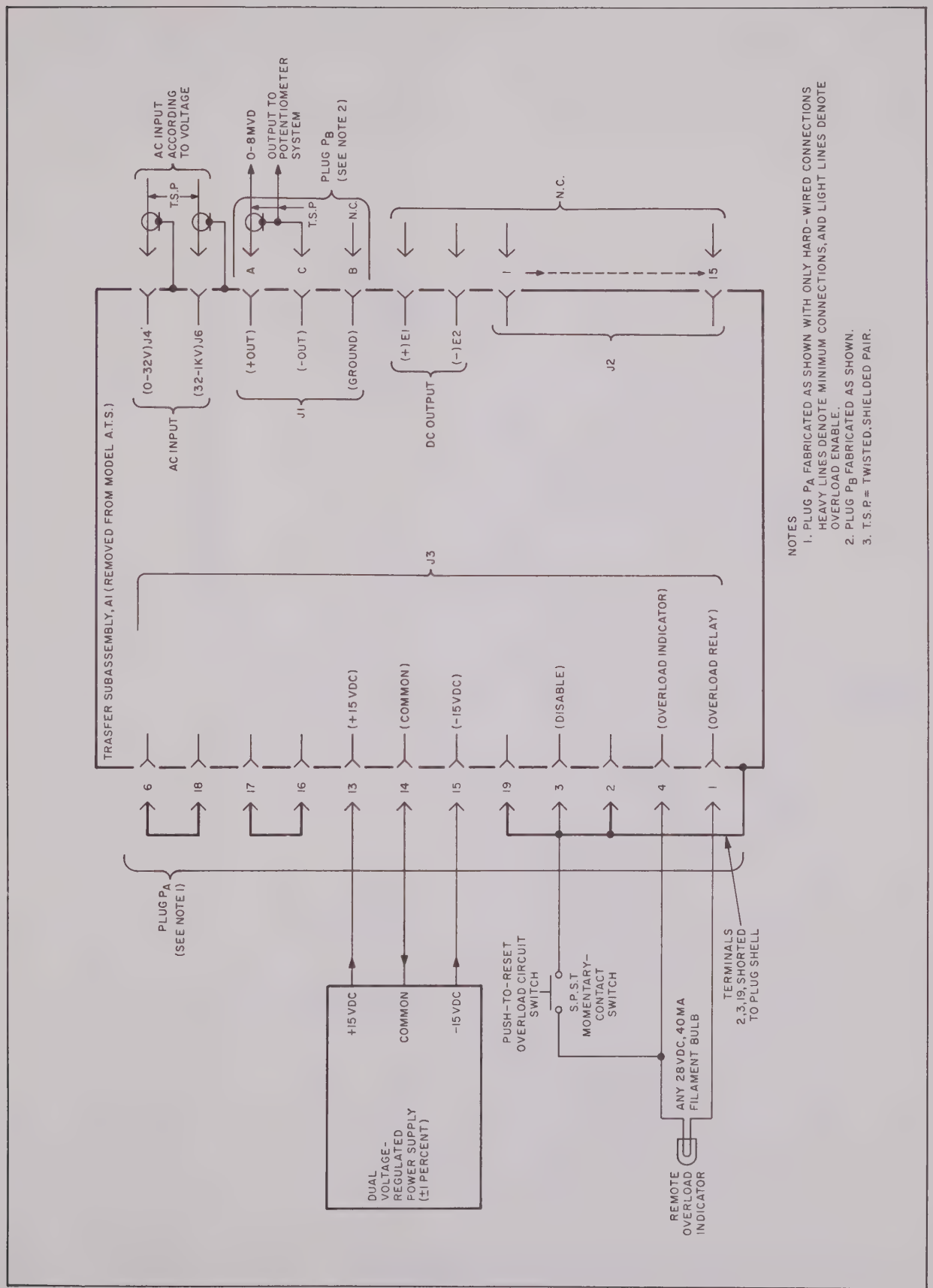


Figure 2-6. Interconnection Diagram for Independent Operation of Transfer Assembly

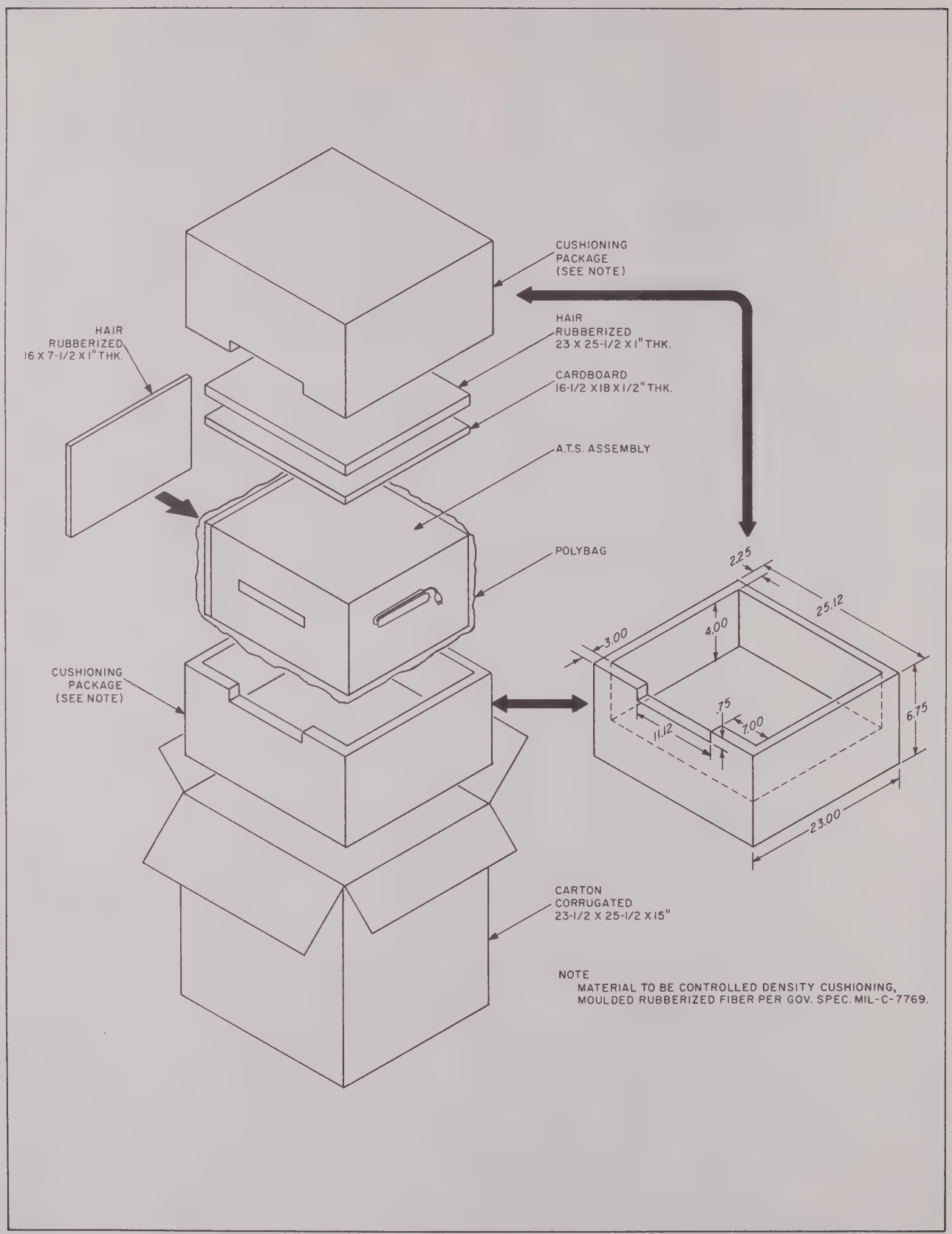


Figure 2-7. Packaging Diagram

a. If the original wrappings and carton have been saved, package the equipment as illustrated in figure 2-7.

b. If new packing material is to be employed, first wrap the ATS in a moistureproof barrier such as a plastic bag. Place the equipment in a suitable box or carton and fill all empty spaces with suitable filler material to prevent possible shifting of the equipment. Seal the box or carton. Should conditions warrant rugged packaging, enclose the sealed box in a carton in an outer wooden crate or metal transit case.

SECTION III
THEORY OF OPERATION

3-1. GENERAL.

3-2. The ATS is a semi-automatic AC-DC transfer standard which provides a d-c output voltage equal to the true rms value of complex (i.e., pulsed, square-wave, triangular-wave and other non-sinusoidal signals having a crest factor of up to 10:1) or sinusoidal signals. The d-c output voltage generated is applied to an auxiliary readout instrument, such as a DC differential or digital voltmeter, which indicates the d-c equivalent to the true rms value of the applied a-c voltage.

3-3. SIMPLIFIED BLOCK DIAGRAM ANALYSIS.

3-4. The ATS consists of 11 major functional circuits interconnected as shown in figure 3-1. A-c signals to be measured are applied to one of two AC INPUT connectors, depending on the signal level, and are applied to a removable transfer assembly which contains attenuators, a thermoelement and an overload protection circuit. The applied a-c signal is attenuated by a resistive attenuator network controlled by the RANGE VOLTS switch so that the voltage coupled to the thermoelement heater elements does not exceed its maximum voltage rating of approximately 0.4 volts rms.

3-5. An overload protection circuit is located between the attenuator output and thermoelement heater to disconnect the applied signal from the attenuator should the signal be greater than the measurement range selected by the RANGE VOLTS switch.

3-6. The thermoelement being an rms responding device, develops a d-c output related to the rms value of the attenuated input signal. Since the thermoelement has a maximum output level of approximately 7 millivolts, this low level d-c voltage is chopped and fed to an amplifier. The use of a chopper/amplifier eliminates the drift problems normally associated with the measurement of low-level d-c voltages.

3-7. MANUAL BALANCE OPERATION. When the mode selector switch is set to MANUAL BALANCE and the AC indicator is illuminated, the operator adjusts the settings of the MANUAL BALANCE COARSE and MANUAL BALANCE FINE controls until the voltage at the input to the chopper is 0 volts. At this point the front panel meter indicates a null. When the operator momentarily depresses the TRANSFER-RESET pushbutton switch, the DC indicator illuminates and the output of either the low or high voltage amplifier is coupled to the same attenuator and the applied a-c signal under measurement is disconnected. Since the output of the applicable voltage amplifier was 0 volts at the moment of transfer, the thermoelement output will decrease immediately after transfer. This results in the generation of an error voltage which is fed to the chopper. The polarity of this error voltage is such to cause the amplifier to drive the thermoelement so that the error voltage is reduced to zero. At this time the d-c output of the voltage amplifier, which is present at the DC OUTPUT binding posts, is equal to the rms value of the applied a-c signal.

3-8. AUTO OPERATION. When the mode selector switch is set to AUTO, the AC indicator illuminates and the a-c signal under measurement is coupled to the thermoelement in the same manner as for manual balance operation. The d-c output of the thermoelement is chopped, amplified, and applied to a memory circuit which automatically develops a d-c voltage which balances the thermoelement output. At this point the voltage amplifier output is 0 volts and the meter indicates a null. After a short delay interval, the transfer circuitry is automatically triggered and the output of the voltage amplifier is coupled to the attenuator and the applied a-c signal is disconnected. The resulting action is identical to that for the manual transfer mode.

3-9. MANUAL TRANSFER MODE. The manual transfer mode is virtually identical to the automatic transfer mode except that the transfer is accomplished by depression of the TRANSFER-RESET pushbutton switch instead of being automatic.

3-10. DETAILED THEORY OF OPERATION.

3-11. TRANSFER ASSEMBLY A1. Transfer assembly A1 (Model ATS-TA) contains the major components of the transfer standard, and can be employed as a conventional AC/DC transfer standard when removed from the ATS. The transfer assembly contains the range selector switch and associated resistive attenuators, a thermoelement, and an overload protection circuit as well as a power supply for operation of the reed relays.

3-12. Range Selection. Since the thermoelement has a maximum rated input voltage of 0.4 volts rms, the applied a-c signal to be measured must be attenuated so that the thermoelement is not damaged. Attenuation of the signal is accomplished by two attenuator networks both controlled by RANGE VOLTS switch A1S3.

3-13. When the RANGE VOLTS switch is set to measure any voltage between 0.25 and 32 volts (see figure 3-2) and the overload protection circuit (refer to paragraph 3-15) is not triggered, A1A1Q9 is

monitored by a peak-sensing overload protection circuit (see figure 5-4). Under normal operation conditions in the a-c balance state, the voltage coupled to the gate of A1A1Q1, part of a high input impedance differential preamplifier. The high impedance provided by the field effect transistor ensures that the waveform coupled to the thermoelement is not distorted and does not load the thermoelement.

3-16. The outputs of the differential preamplifiers, taken at the collectors of A1A1Q3 and A1A1Q4, detected by A1A1CR1 and A1A1CR2 and summed across A1A1R10. Should the peak voltage level of the a-c peak voltage level of the a-c signal coupled to the thermoelement exceed 1.75 times the value of the selected RANGE VOLTS scale rms voltage, the positive-going voltage at the collector of A1A1Q5 drives A1A1Q7 into conduction. This causes the collector voltage of A1A1Q7 to rise positively and trigger silicon controlled rectifier A1A1Q8 into conduction, cutting off A1A1Q9. When A1A1Q9 is driven into cutoff, a ground return path for the attenuator multiplier selection relays is no longer provided and the applied signal is disconnected from the thermoelement. Note that the overload protection circuit can be reset (after the overload condition has been removed) by depressing OVERLOAD PROTECTION PUSH TO RESET switch S2. The overload protection circuitry can be disabled by holding OVERLOAD PROTECTION PUSH TO DISABLE switch S3 depressed.

3-17. Thermoelement A1TC1. The output of either the low voltage or high voltage attenuator (depending on the setting of the RANGE VOLTS switch) is applied to the heater of thermoelement A1TC1. The thermoelement which is a heat-sensitive device, produces a d-c output voltage proportional to the power level (square of the applied rms voltage) coupled to its heater element. The d-c output of the thermoelement is applied in series with R3 to chopper G1.

3-18. MANUAL BALANCE MODE. The following discussion assumes that the RANGE VOLTS switch is set to 0.5 to 1.0.

3-19. A-C Balance. In the a-c balance state of operation, coil A1L1, which controls low-voltage input switch A1S4, is energized (see figure 3-4). When this coil is energized, the normally open contacts of switch A1S4 close. The a-c input is applied to the heater portion of thermoelement A1TC1 through closed contacts of low-voltage input switch A1S4, input reed relay A1S11, and resistor A1R7. The thermoelement produces a d-c output in series with resistor R3 that is applied as an input to the chopper system consisting of chopper G1 and transformer T3. The output of T3 is then applied to chopper amplifier A2. Simultaneously, a d-c reference voltage of opposite polarity, taken from the 3.9 volt reference power supply, is applied (through MANUAL BALANCE controls R1 and R2) across resistor R3 and into the chopper amplifier system. Since these two voltages are opposite in polarity, they tend to cancel each other, therefore only their difference remains as an input to the chopper amplifier. (For a detailed description of the chopper amplifier circuitry refer to paragraph 3-37.) The output of chopper amplifier is supplied as an input to DC amplifier and filter A3. The DC amplifier and filter provides amplification to two different voltage levels. One output (terminal 14) is applied to the panel null meter through normally closed contacts of de-energized transfer relay K1-8 and TRANSFER CHECK switch S5. This provides the operator a visual indication of balance between the two opposing input voltages. A higher level output (terminal 3) is used as an input to the low voltage amplifier A4. (For a detailed description of the DC amplifier and filter, refer to paragraph 3-38.) The low voltage amplifier (refer to paragraph 3-40) develops the transfer voltage that is equal to the rms value of the unknown a-c input voltage. Its output (terminal 9) is not used during the a-c balance.

3-20. To transfer from the a-c balance to the d-c output states, the operator pushes the TRANSFER RESET pushbutton. This action provides a ground return path for the coil of transfer relay K1, which is already connected to a +28VDC supply. Relay K1, thus energized, opens its normally-closed contacts and closes its normally-open contacts, thereby changing the overall circuit configurations and establishing the d-c output state.

3-21. DC Output State. In the d-c output state, the magnetic coil A1L1 that controls low-voltage input switch A1S4 is de-energized. When this coil is de-energized, the original a-c input voltage is replaced by its d-c equivalent provided by the low voltage amplifier at terminal 9. This d-c equivalent voltage is made available at the DC OUTPUT terminals (through the closed contacts now-energized transfer relay K1-6) for external measurement. Observe that the DC OUTPUT terminals were previously grounded during the a-c balance state through closed contacts de-energized transfer relay K1-6. This means that a d-c output is available only in the d-c output state.

3-22. The -15 volt supply provides 100 microamperes current to the zero-center reading panel meter M1 via normally open-contact of energized transfer relay K1-8 and TRANSFER CHECK switch S5. This current deflects the meter pointer toward the left edge of the meter scale graduations, converting the instrument into a conventional left-to-right voltage indicating meter. Simultaneously, the transfer voltage output available to the DC OUTPUT terminals is applied through resistor A1R16 to the panel meter. Thus the panel meter gives a moderately accurate (±5%) indication of the value of the transfer voltage.

3-23. AUTO MODE. The following description of the operation of the ATS in the AUTO mode assumes that a high-voltage a-c input of 32 to 64 volts is to be measured.

3-24. A-C Balance. In the a-c balance state, energizing power is applied to relays A1K10, A1K19, A1K20, and coil A1L10 associated with reed relay A1S13. The high-voltage a-c input is applied to the heater of thermoelement A1TC1 through closed contacts of high-voltage input relay A1K10, front attenuator relay A1K19, attenuator resistor A1R39, rear attenuator relay A1K20 and high-voltage isolation

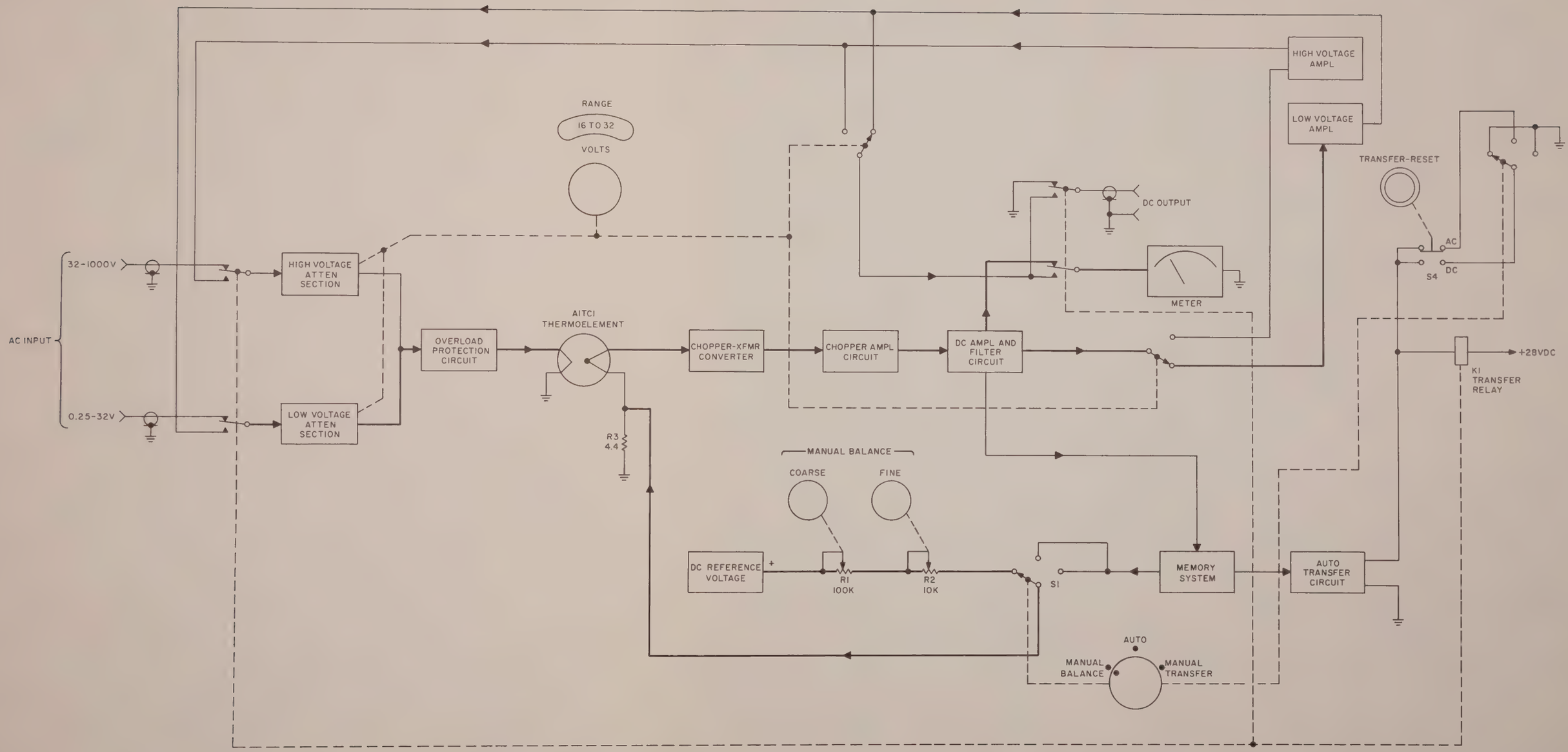


Figure 3-1. Simplified Block Diagram

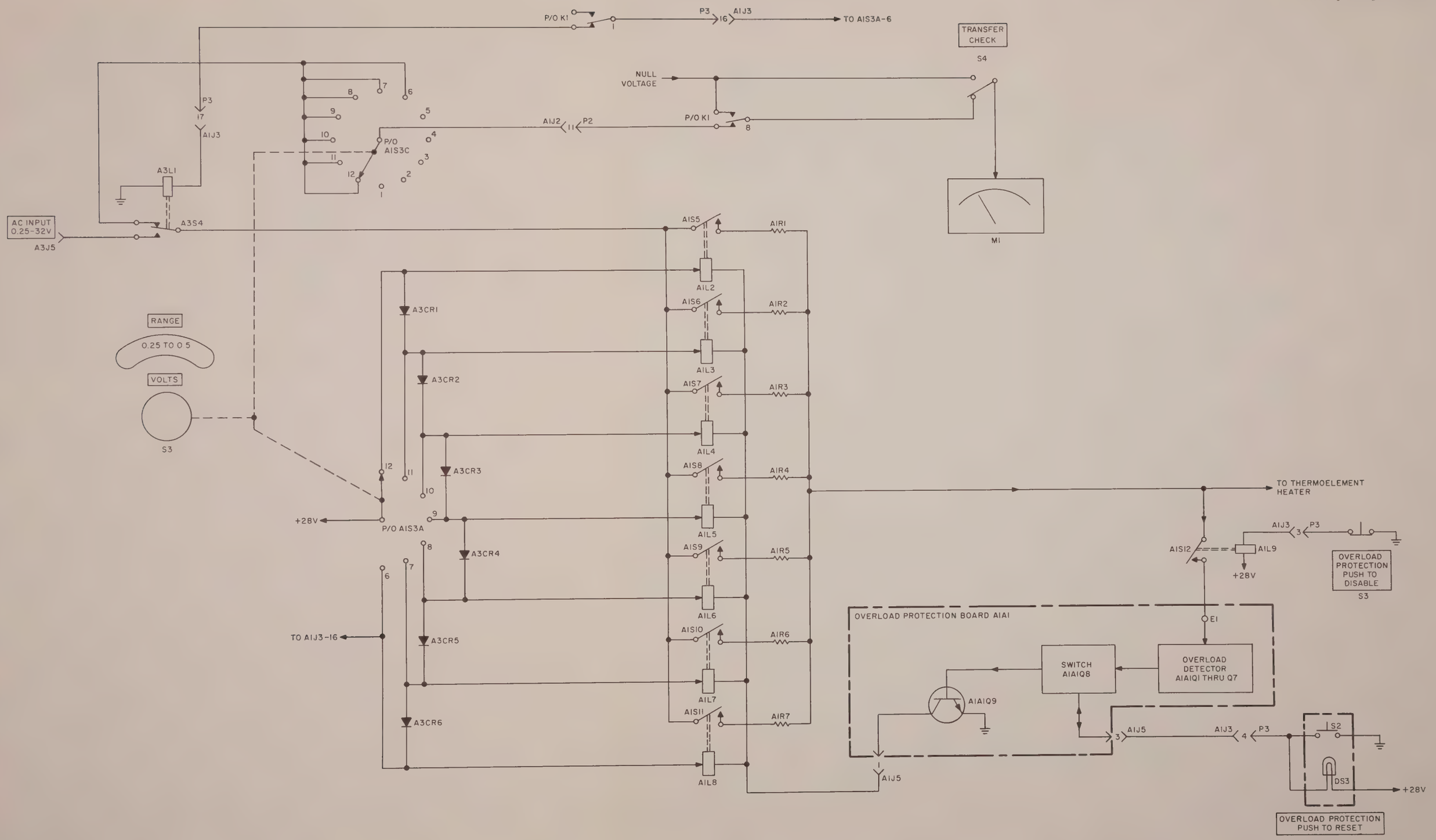


Figure 3-2. Low Voltage Attenuator, Detailed Block Diagram

conducting heavily and its collector is near ground. When the ATS is in the a-c balance state and the RANGE VOLTS switch is set to 0.25 TO 0.5, +28 volts is coupled to the coil of A1L2 and, through steering diodes A1CR1 through A1CR6, to the coils of A1L3 through A1L8. The contacts of reed relays A1S5 through A1S11 are closed and resistors A1R1 through A1R8 are placed in parallel to form an equivalent 20-ohm resistor. This resistor, in series with the thermoelement heater, limits the voltage applied to the 80-ohm heater element at 0.4 volts. As the RANGE VOLTS switch is rotated clockwise (see table 3-1) up to the 16 TO 32 position, steering diodes A1CR1 through A1CR6 successively become back biased and cause A1L2 through A1L7 to become de-energized. This results in the effective series multiplying resistance of the attenuator to increase. Since the ATS is in the a-c balance state, transfer relay K1 is energized and +28 volts is applied to A1A1; this causes the contacts of A1S4 to close and couple the applied a-c signal from AC INPUT 0.25 - 32V connector A1J4 to the input of the low voltage attenuator. Note that, when the RANGE VOLTS switch is set for voltages above 32 volts, A1L1 is no longer coupled to the +28-volt supply and the contacts of A1S4 open to disengage A1J4 from the low voltage attenuator.

3-14. When the RANGE VOLTS switch is set to measure any voltage between 32 and 1000 volts (see figure 3-3) and the overload protection circuit is not triggered, A1A1Q9 is conducting heavily and its collector is near ground. When the ATS is in the a-c balance state and the RANGE VOLTS switch is set to 32 TO 64, +28 volts is coupled to the coils of paralleled relays A1K19 and A1K20. The normally-open contacts close and insert resistor A1R39 in series with the thermoelement heater. As the RANGE VOLTS switch is rotated clockwise (see table 3-2), relay pairs are energized to insert the proper value resistance multiplier. Since the ATS is in the a-c balance state, +28 volts is applied across the coils of relays A1K10 and A1K22. Energization of A1K10 couples the signal at the AC INPUT 32 - 1000V connector A1J6 through the selected multiplier and energization of A1K22 applies the attenuated signal to the heater of A1TC1. Note that, when the RANGE VOLTS switch is set for voltages below 32 volts, relays A1K10 and A1K22 become de-energized to open-circuit the voltage applied at A1J6 and disconnect the high voltage attenuator output from the thermoelement input.

3-15. Overload Protection Circuitry. The voltage applied to the heater of thermoelement A1TC1 is

TABLE 3-1. LOW VOLTAGE ATTENUATOR OPERATION

RANGE VOLTS Switch Setting	Relay Coils Energized	Resistors Placed in Parallel	Effective Series Resistance	Signal Attenuation
0.25 TO 015	A1L2 thru A1L8	A1R1 thru A1R7	20 Ω	1.25:1
0.5 TO 1.0	A1L3 thru A1L8	A1R2 thru A1R7	120Ω	2.5:1
1 TO 2	A1L4 thru A1L8	A1R3 thru A1R7	320Ω	5:1
2 TO 4	A1L5 thru A1L8	A1R4 thru A1R7	725Ω	10:1
4 TO 8	A1L6 thru A1L8	A1R5 thru A1R7	1.5KΩ	20:1
8 TO 16	A1L7 thru A1L8	A1R6 and A1R7	3.1KΩ	40:1
16 TO 32	A1L8	A1R7	6.32KΩ	80:1

TABLE 3-2. HIGH VOLTAGE ATTENUATOR OPERATION

RANGE VOLTS Switch Setting	Relays Energized	Resistor(s) Inserted	Effective Series Resistance	Signal Attenuation
32 TO 64	A1K19 and A1K20	A1R39	12.7KΩ	160:1
64 TO 125	A1K17 and A1K18	A1R37 and A1R38	24.8KΩ	312:1
125 TO 250	A1K15 and A1K16	A1R34 thru A1R36	50.7KΩ	645:1
250 TO 500	A1K13 and A1K14	A1R29 thru A1R33	100KΩ	1250:1
500 TO 1000	A1K11 and A1K12	A1R19 thru A1R28	200KΩ	2500:1

reed switch A1S13. The thermoelement produces a d-c output in series with resistor R3 that is applied as an input to the chopper system consisting of chopper G1 and transformer T3. The chopper and transformer combination converts the d-c thermoelement output into a 60-Hz square-wave voltage which is applied as an input to the chopper amplifier A2. The chopper amplifier circuit amplifies the square-wave voltage, demodulates it, then passes it along as an input to the DC amplifier and filter A3. (For a detailed description of the chopper amplifier, refer to paragraph 3-37).

3-25. The DC amplifier and filter circuit provides three different output voltage levels. A low-level d-c output (terminal 14) is applied to the panel null meter through normally-closed contacts of de-energized transfer relay K1-8 and TRANSFER CHECK switch S5. A higher-level d-c output (terminal 13) is applied as an input to a comparator circuit on the clock and gating board through wafer C of the mode switch S1. A still higher-level d-c output (terminal 3) is applied as an input to the high voltage amplifier A12. (Refer to paragraph 3-38 for a detailed description of the DC amplifier and filter circuitry.)

3-26. The comparator (zero detector) circuit on clock and gating board A8, which obtains its input at terminal A from the DC amplifier and filter circuit, controls the 16-stage up/down binary counter consisting of the two 8-Stage F/B counter boards A6 and A7. The comparator circuit (see figure 5-9) determines whether the counter should count up or down to achieve a balance of the ATS transfer standard. Since only the resultant of the applied a-c input voltage appears across resistor R3 at this time, the counter must be commanded to count upward to develop a reference d-c voltage related to the a-c input voltage. The comparator circuit, composed of complementary transistors A8Q1 and A8Q5, senses the presence and polarity of a voltage input at terminal A, and responds accordingly. A positive voltage existing at terminal A turns transistor A8Q1 on and transistor A8Q5 off. A negative voltage at terminal A has the opposite effect. If no voltage is present at terminal A, both transistors are turned off. Since no reference d-c voltage has been developed at this time, a positive voltage appears at terminal A, therefore transistor A8Q1 is turned on and transistor A8Q5 is turned off. Transistor A8Q2 is also turned off since it is connected in the collector circuit of A8Q5.

3-27. The logic state of the gating circuits associated with the comparator output is such that the voltage levels at output terminals 4 and 3 are high, and those at terminals 5 and 2 are low. Meanwhile, a clock oscillator, consisting of transistors A8Q6 and A8Q9, provides trigger pulses which, in conjunction with the comparator outputs, advances the counter upward. As the counter advances upward it drives the ladder and buffer amplifier network A5 which, in turn, progressively builds up a reference voltage that is applied across resistor R3 through wafer D of mode switch S1. The polarity of this reference voltage is such that it tends to cancel or "buckout" the resultant of the original a-c input voltage. Thus only the difference between the two voltages remains as an input to the chopper amplifier circuit.

3-28. When the reference voltage builds up to a level equal to the applied a-c input voltage, there is no difference voltage applied to the chopper amplifier circuit and consequently none to the comparator circuit. Therefore transistors A8Q1, A8Q5, and A8Q2 are all turned off. The logic state of the gates associated with the comparator circuit output is such that the voltage levels at output terminals 4 and 2 are low, and those at terminals 3 and 5 are high. Thus the 16-stage counter receives no further command to count upward, so it stops counting.

3-29. The 16-stage binary counter is composed of two 8-Stage F/B counter boards, A6 and A7, connected together in cascade. These boards are identical and interchangeable (see figure 5-8). Each contains a typical arrangement of flip-flops (bistable multivibrators) and NAND gates, but their interconnection is such that the counter has the capability of counting downward as well as upward. In counting downward, the complementing level change comes from the 0 terminal of the preceding flip-flop rather than the 1 terminal. The counting sequence is the reverse of up counting. The operation of the counter is controlled by the clock and gating circuit A8. Commands to the counter from the clock and gating circuit arrive at terminals R.S.K. P, and 12. The logic of the gating system is such that when the voltage input levels at terminals R and K are high and those at 12 and S are low simultaneously with a low-level clock pulse at terminal P, the counter is triggered upward. Conversely, when the voltage input levels at terminals R and K are low and those at terminals 12 and S are high simultaneously with a low-level clock pulse at terminal P, the counter is triggered downward. When the voltage input levels at terminals R and S are low and those at terminals 12 and K are high simultaneously with a low-level clock pulse at terminal P, the counter does not trigger at all.

3-30. The ladder (figure 5-7) is a voltage decoding network driven by the binary counter so that each step of the counter is decoded into a different voltage level. Starting from 0 volts, the d-c reference voltage increases in a stepwise manner as the count increases. Since the clock drives the counter, each step results in a count and voltage change by one increment. When the counter steps downward, of course, the ladder output voltage decreases in a corresponding manner.

3-31. If, for any reason, the counter should arrive at its maximum or minimum capacity before the d-c reference voltage is developed, a gating circuit on the clock and gating board automatically stops the counter. Inputs for this gating circuit are derived from comparator circuit outputs along with the three topmost counter outputs and their respective complements.

3-32. After the d-c reference voltage is developed and the counter is stopped, there follows a six second time delay interval during which the ATS waits for

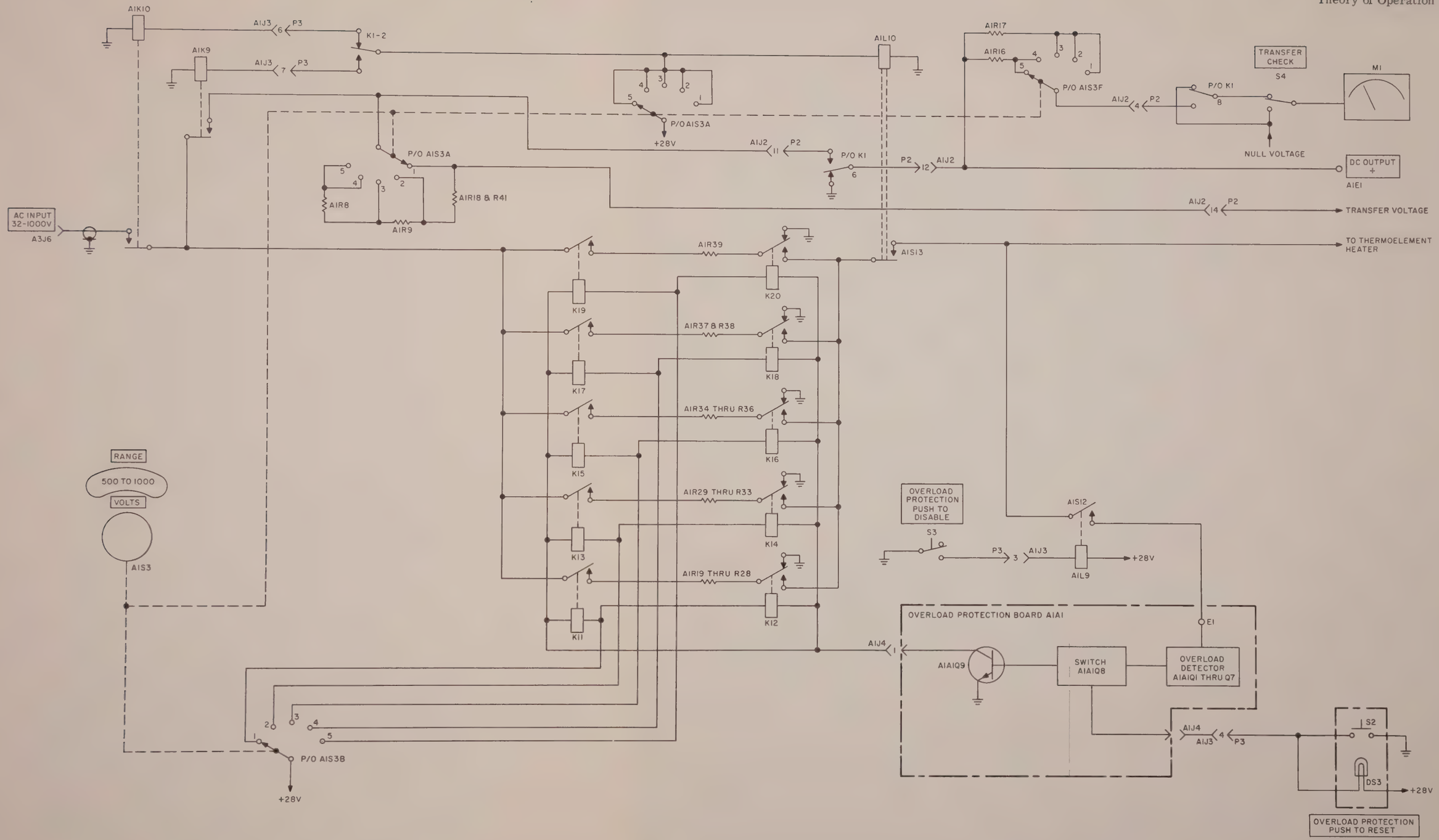
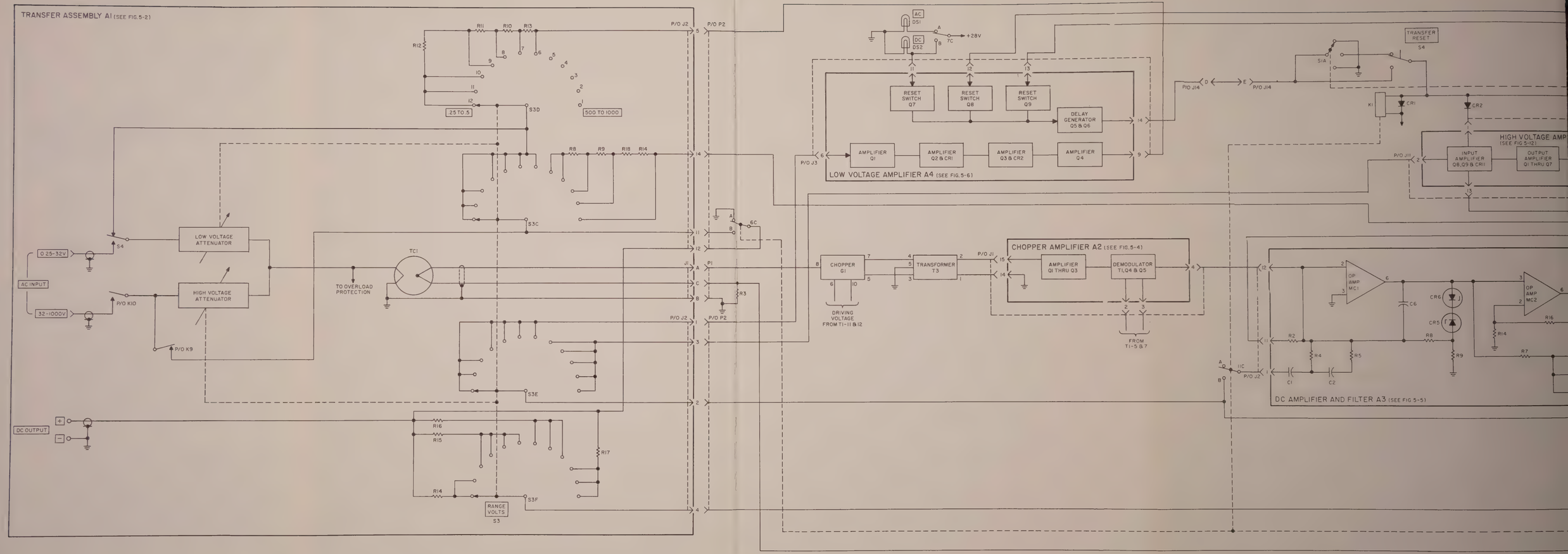


Figure 3-3. High Voltage Attenuator, Detailed Block Diagram


TRANSFER ASSEMBLY A1 (SEE FIG. 5-2)
AC INPUT
0.25-32V
32-1000V
S4
P/O K10
P/O K9
LOW VOLTAGE ATTENUATOR
HIGH VOLTAGE ATTENUATOR
TO OVERLOAD PROTECTION
TC1
R11
R10
R13
R12
25 TO 5
S3D
500 TO 1000
R8
R9
R18
R14
S3C
S3E
R16
R15
R17
R14
RANGE VOLTS S3
S3F
DC OUTPUT
P/O J2
P/O P2
6C
R3
AC DS1
DC DS2
+28V
1C
RESET SWITCH Q7
RESET SWITCH Q8
RESET SWITCH Q9
DELAY GENERATOR Q5 & Q6
AMPLIFIER Q1
AMPLIFIER Q2 & CR1
AMPLIFIER Q3 & CR2
AMPLIFIER Q4
P/O J3
LOW VOLTAGE AMPLIFIER A4 (SEE FIG. 5-6)
P/O J14
TRANSFER RESET S4
S1A
K1
CR1
CR2
HIGH VOLTAGE AMP (SEE FIG 5-12)
P/O J11
INPUT AMPLIFIER Q8,Q9 & CR11
OUTPUT AMPLIFIER Q1 THRU Q7
CHOPPER G1
TRANSFORMER T3
DRIVING VOLTAGE FROM T1-11 & 12
CHOPPER AMPLIFIER A2 (SEE FIG. 5-4)
AMPLIFIER Q1 THRU Q3
DEMODULATOR T1, Q4 & Q5
FROM T1-5 & 7
OP AMP MC1
OP AMP MC2
C6
CR6
CR5
R2
R4
R5
R8
R9
R16
R14
R7
C1
C2
DC AMPLIFIER AND FILTER A3 (SEE FIG 5-5)

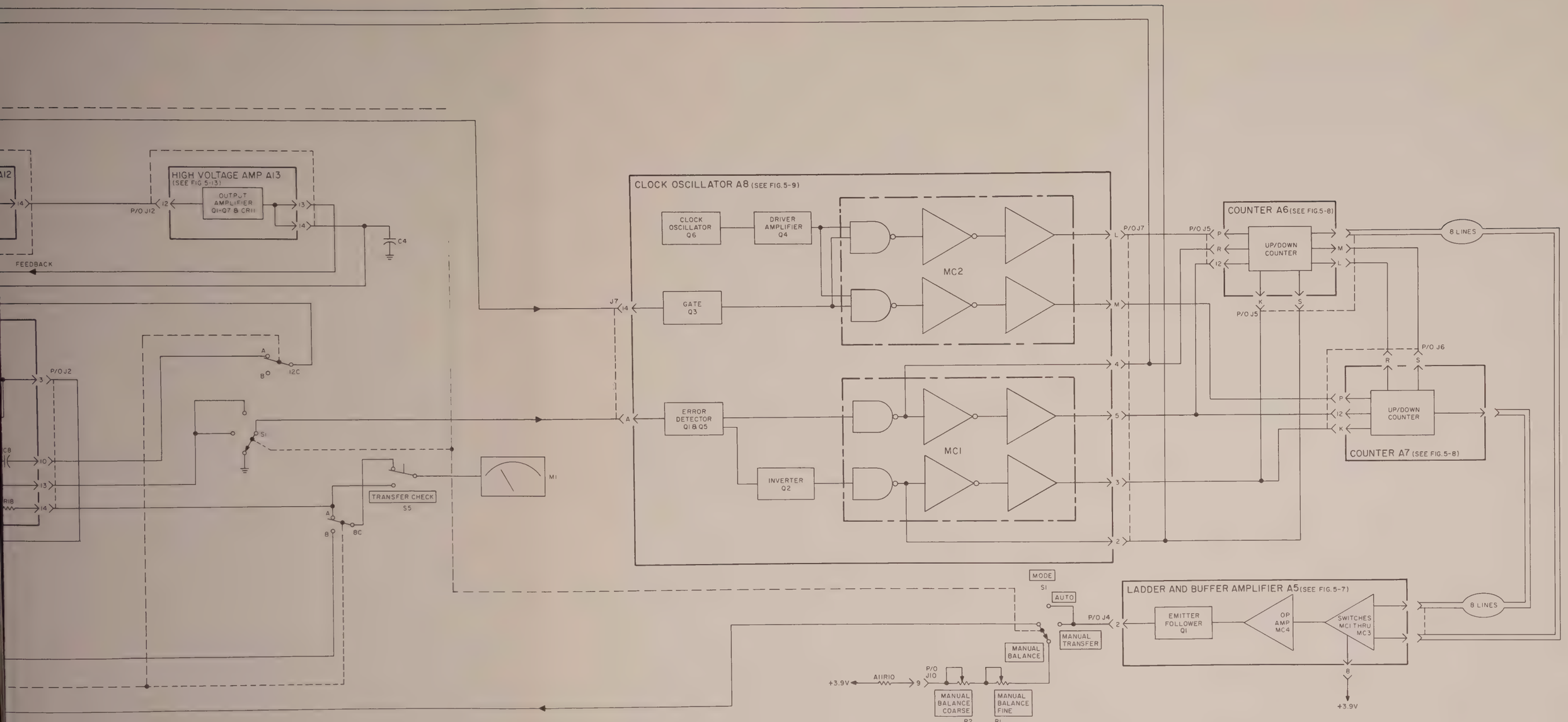


Figure 3-4. Detailed Block Diagram

any change in the value of the applied a-c input voltage. This delay is accomplished by means of a 3-transistor NOR gate and a capacitor connection in the automatic transfer circuit (see figure 5-6). The NOR gate consists of transistors A4Q7, A4Q8, and A4Q9. When the counter is commanded to count upward, a positive voltage is applied to the base of transistor A4Q9 through board terminal 12. This voltage turns the transistor on and thereby effectively short-circuits capacitor A4C4, which is connected to the emitter of unijunction transistor A4Q6. Thus the unijunction is quiescent and silicon controlled rectifier A4Q5 is nonconducting. Conversely, when the counter is commanded to count downward, a positive voltage is applied to the base of transistor A4Q8 through board terminal 13, producing the same results. (The third transistor A4Q7 is turned on only when the ATS transfers to the d-c output state.) The time delay interval begins when all three transistors are turned off, i.e., the counter is ordered to stop counting. Capacitor A4C4 begins to charge up to the predetermined level necessary to fire the unijunction transistor, which takes approximately six seconds. When the unijunction transistor fires, it triggers the SCR which, in turn, begins to conduct. Since the ground return terminal of transfer relay K1 is connected to board terminal 14 and +28 vdc power is already connected, the relay is energized through the conducting SCR. Thus energized, transfer relay K1 opens its normally closed contacts and closes its normally open contacts, thereby transferring the ATS from the a-c balance to the d-c output state.

3-33. DC Output State. In the d-c output state, relay A1K10 is de-energized and relay A1K9 is energized instead. Thus the high-voltage a-c input to the thermoelement circuit is removed and replaced by an equivalent d-c voltage from terminal 14 of high voltage amplifier 2, A13. This d-c voltage, which will exactly balance the reference voltage output from the ladder and buffer amplifier, is the transfer voltage made available at the DC OUTPUT terminals through transfer relay contacts K1-6 for external measurement.

3-34. Normally-closed transfer relay contacts K1-8 that provided an indication of balance (null) to the panel meter in the AC state are now transferred to provide a needle pointer offset negative voltage (left-to-right dial conversion) and a voltage level indication. Terminals 10 and 11 of the DC amplifier and filter board, previously tied together through normally-closed contacts K1-12, are disconnected and terminals 1 and 3 are connected together instead (through normally-open contacts K1-11) for the d-c output state configuration.

3-35. MANUAL TRANSFER MODE. The MANUAL TRANSFER mode of operation incorporates features of both the MANUAL BALANCE and AUTO modes. The procedures for setting up and operating the ATS in MANUAL TRANSFER is exactly the same as for AUTO mode, and the equipment performance is the same throughout the a-c balance state, except that no automatic transfer to the d-c output state occurs. When a balance of a-c rms value versus d-c reference voltage is achieved, the ATS simply waits for the operator to make the transfer by pushing the TRANSFER RESET pushbutton switch S4. If the magnitude of the a-c input voltage changes (before transfer is made) within the limits of the RANGE VOLTS switch position, the ATS will seek a new balance and wait again.

3-36. AMPLIFIER CIRCUIT BOARDS. Chopper amplifier A2 and the DC amplifier and filter A3 are involved in all three modes of operation and in both the a-c balance and d-c output states. Either the low voltage or the high voltage amplifier, depending upon the magnitude of the voltage being measured, is involved in all three modes in the d-c output state.

3-37. Chopper Amplifier A2. To amplify the low voltage generated by the thermoelement, it is necessary to avoid the drift problem introduced by a direct-coupled amplifier and use a-c amplification instead. In the ATS, the thermoelement d-c output voltage is converted into a 60-Hz square wave voltage (by chopper G1) that then is amplified by chopper amplifier A2 (see figure 5-4). Transistors A2Q1, A2Q2, and A2Q3 provide three stages of amplification, the output is applied to the primary winding of transformer A2T1. A phase-sensitive demodulator circuit, composed of the secondary winding of transformer A2T1 and transistors A2Q4 and A2Q5 with their associated components, converts the amplified a-c voltage back into a d-c voltage. The demodulator portion of the system is driven by a center-tapped winding on power transformer T1.

3-38. DC Amplifier And Filter A3. Two interconnected high-gain operational amplifiers (A3MC1 and A3MC2) comprise the DC amplifier and filter (see figure 5-5). The output from the shopper amplifier is applied to the inverting input terminal 2 of amplifier A3MC1. Thus the output of amplifier A3MC1 is opposite the polarity of the input voltage. This output is applied through resistor A3R7 to the comparator circuit on the clock and gating board and through resistor A3R18 to the panel null meter. It is also applied through resistor A3R13 as an input to the non-inverting input terminal 3 of amplifier A3MC2. The output from amplifier A3MC2 serves as the input to either low voltage amplifier A4 or high voltage amplifiers A12 and A13, depending upon the magnitude of the voltage being measured.

3-39. In the a-c balance state of operation, terminals 10 and 11 of the DC amplifier and filter are tied together through transfer relay contacts K1-12. In the d-c output state, terminals 1 and 3 are tied together through transfer relay contacts K1-11. These connections provide low frequency phase compensation to prevent circuit oscillation. Diodes A3CR1 through A3CR4 limit the input voltage to the operational amplifiers and diodes A3CR5 and A3CR6 provide a non-linear characteristic to the panel meter null scale.

3-40. Low Voltage Amplifier A4. The voltage input for the low voltage amplifier board at terminal 6 (see figure 5-6) arrives from the DC amplifier and filter board. Transistors A4Q1 through A4Q4, connected in cascade, provide four stages of amplification

with an output appearing off the emitter of transistor A4Q4 at terminal 9. Since the output of the low voltage amplifier must go up to 32 volts, the collector voltage for the final two stages is +43 volts; provided by a separate power supply on the circuit board.

3-41. High Voltage Amplifiers A12 and A13. Two circuit boards are needed to mount the components comprising the high voltage amplifier function (see figure 5-12). The input for the high voltage amplifier arrives from the DC amplifier and filter at terminal 2. It is amplified by a cascade combination of transistors A12Q9 and A12Q8, then fed into the bottom transistor (A12Q1) of a series array of transistors composed of transistors A12Q1 through A12Q7 and A13Q1 through A13Q7. This "totem pole" arrangement enables us to produce up to the 1000-volts output required for the higher a-c input voltages with relatively low voltage transistors.

3-42. POWER SUPPLIES. Seven different rectifier power supplies provide the power required by the ATS. They are physically located at various places within the unit.

3-43. +28 VDC Power Supply. Inside transfer assembly A1 is the rectifier power supply providing the power for energizing control relays and reed switch coils. (See figure 5-1.) Essentially, it is a conventional diode bridge rectifier circuit drawing power from the secondary winding of transformer A1T1. Filtering is accomplished by resistor A1R40 and capacitor A1C1. Pushbutton POWER PUSH illuminating lamp DS1 is connected across the power supply output and energized when the ATS is turned on.

3-44. ±15-Volt Power Supplies A9 and A10. Two identical circuit boards provide the positive and negative 15-volt power required for operation of balanced transistor circuits and operational amplifier packages on nine circuit boards (see figure 3-5). The negative output terminal of one of these is grounded and the positive output terminal forms the +15 volt supply line. The positive output terminal of the other 15-volt power supply is grounded and the negative output terminal forms the -15 volt supply line. Since both power supply circuits are the same, it is necessary to consider only one for purposes of analysis. The schematic diagram is shown in figure 5-10.

3-45. The 15-volt power supply is a conventional series-regulator power supply with a differential amplifier circuit composed of transistors A9Q2 and A9Q3 used as the error amplifier. Transistors A9Q1 and A9Q4 form the series-regulating element and the reference voltage is obtained from Zener diode A9CR3. Zener diode A9CR4 provides collector bootstrapping for the error amplifier and potentiometer A9R7 provides adjustment of the output voltage. A9Q5 provides overcurrent protection. Full-wave rectification of power derived from a secondary winding of transformer T1 is accomplished by diodes A9CR1 and A1CR2.

3-46. +3.6 and +3.9 Volts Power Supply. Two regulated d-c power supplies are developed to provide voltages to the clock and gating circuit with the two counter boards and to the ladder and buffer amplifier network (see figure 3-6). The bridge is driven by a secondary winding of power transformer T1 (see figure 5-11). The +3.6-volt output has a three-transistor series-regulating element consisting of transistors A11Q2, A11Q3, and A1 mounted on the main frame chassis. Transistor Q1 dissipates appreciable heat and the chassis serves as a convenient heat sink. The -15-volt input from the negative 15-volt power supply provides the reference voltage and transistor A11Q4 is the error amplifier. Capacitor A11C2 provides filtering.

3-47. The +3.9-volt power supply provides a voltage to the ladder network from which the transfer reference voltage is developed; hence a very high degree of regulation is needed. Here transistor A11Q1 is the series regulating element. The reference voltage source is Zener diode A11CR1 and operational amplifier MC1 functions as the error amplifier. Capacitor C3 provides filtering.

3-48. +43 Volt Power Supply. A diode bridge rectifier mounted on the board and connected to a secondary winding of power transformer T1 provides power for the operation of low voltage amplifier circuit (see figure 5-6). Filtering is accomplished by means of capacitor A4C5 and resistor A4R12. Zener diode A4CR7 provides regulation.

3-49. +1500-Volt Power Supply. The voltage requirements for operation of the high voltage amplifier circuit (built on two boards) is delivered by a power supply located on the second circuit board A13 (see figure 5-12). A diode bridge consisting of diodes A13CR2 through A13CR5 is driven by the secondary winding of power transformer T2 and filtered by choke L1 and capacitor C1 on the main frame. The output power developed is 1500 d-c volts.

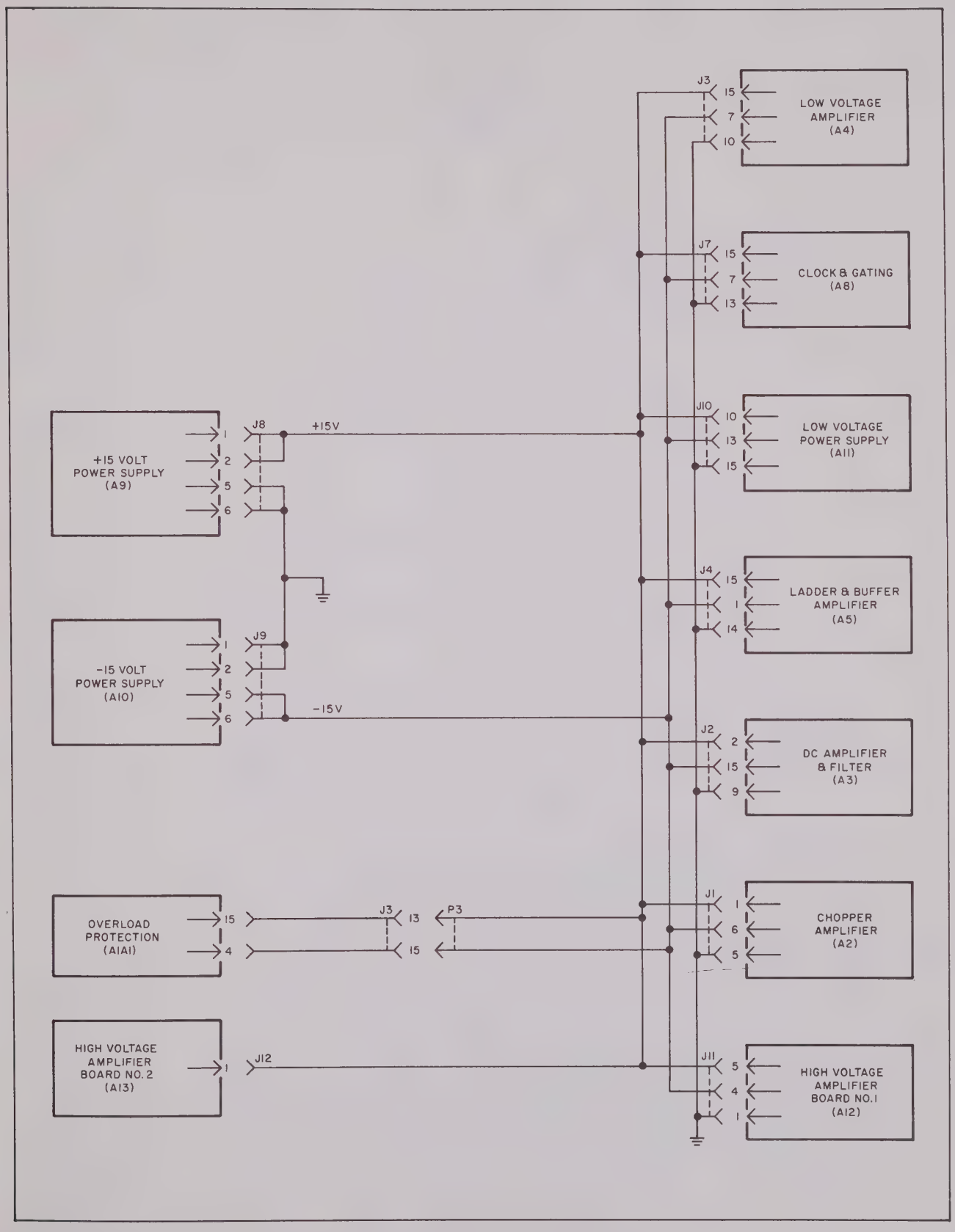


Figure 3-5. ±15 Volt Power Distribution

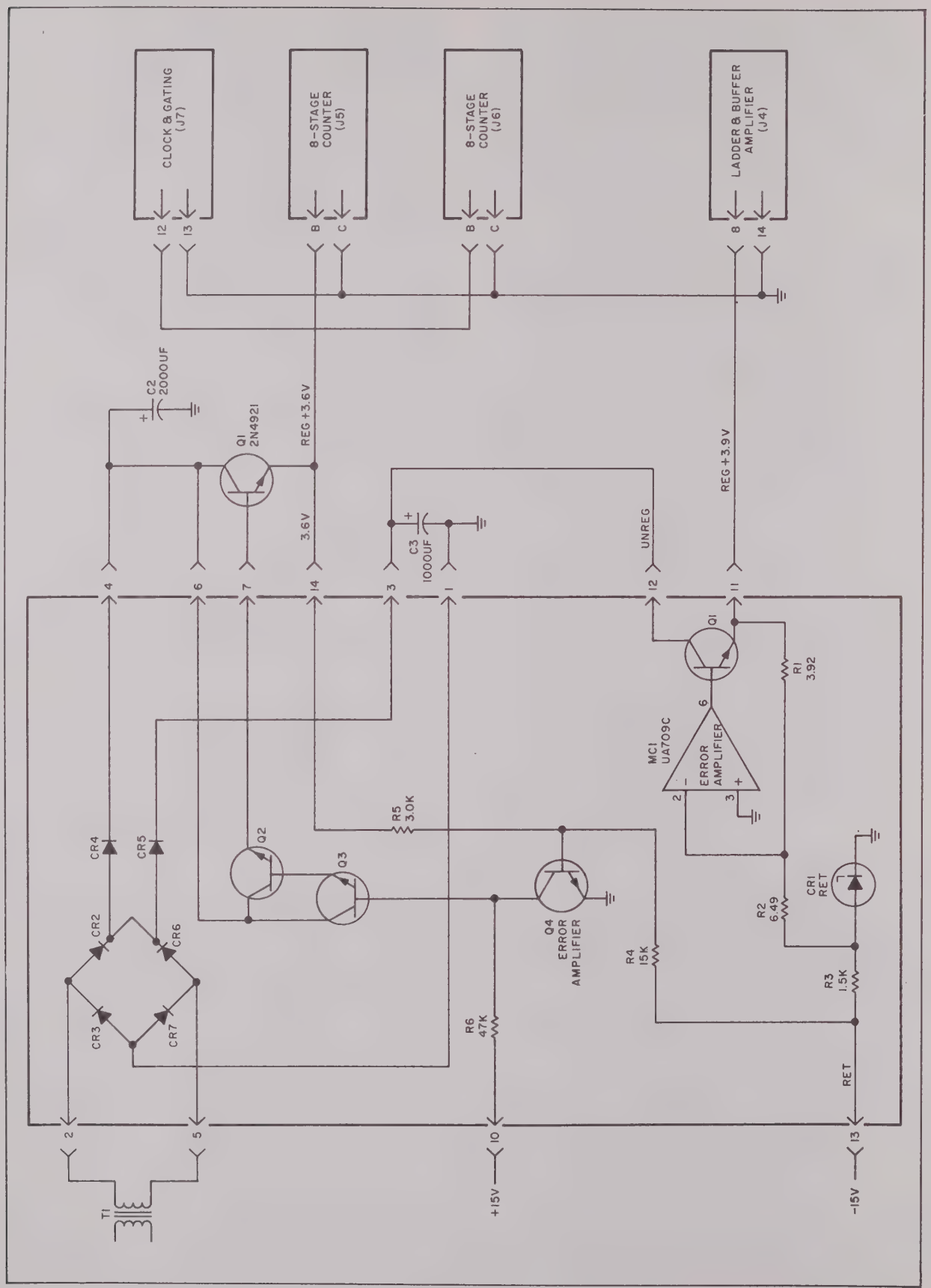


Figure 3-6. +3.6 and +3.9 Volt Power Distribution

SECTION IV
MAINTENANCE

4-1. GENERAL.

4-2. This section contains maintenance, alignment and calibration instructions for the ATS. Included are a list of test equipment necessary for maintenance of the unit, minimum performance standards checks to evaluate whether the equipment operates within published specifications, systematic troubleshooting procedures to localize a malfunction to an individual subassembly or circuit and alignment and calibration procedures necessary to restore the equipment to proper operating condition after the required repairs have been accomplished.

4-3. TEST EQUIPMENT REQUIRED.

4-4. The test equipment required for the maintenance and calibration of the ATS is listed in table 4-1. Equipment having similar characteristics may be substituted for those listed.

4-5. MINIMUM PERFORMANCE STANDARDS CHECKS.

4-6. The minimum performance standards checks are aids to evaluating whether the ATS is functioning within the specifications listed in Section I. Should the ATS fail to provide the normal indication as specified, the equipment is not operating properly, and the operator should refer to the applicable troubleshooting, replacement, repair, alignment and/or calibration procedures to restore the equipment to normal operating condition.

TABLE 4-1. REQUIRED TEST EQUIPMENT

Manufacturer and Model
Kintel 303B DC Power Supply
Sensitive Research LTPS-11A - Variable Frequency AC Power Supply
Sensitive Research FLH-2 - AC-DC Transfer Standard
Leeds & Northrup 2430-C Galvanometer
Dana 5500 Digital Voltmeter
RCA WV98C Senior Voltohmyst

4-7. Two minimum performance checks are provided. The definitive check should be used when another transfer standard (with a NBS test report) is available. The non-definitive check should be used when only a calibrated d-c source is available and does not verify the a-c response specifications.

4-8. DEFINITIVE CHECK. To perform a definitive minimum performance standards checks, proceed as directed in the following steps.

a. Connect the equipment as illustrated in figure 4-1, setup A.

b. Set the RANGE VOLTS switch to 0.25 TO 0.5 and set the mode switch to MANUAL BALANCE.

c. Adjust both the d-c and a-c sources for minimum output level.

d. Energize all equipment and allow sufficient time for stabilization.

e. Check that the AC indicator is illuminated. If the DC indicator is illuminated, depress the TRANSFER RESET pushbutton switch.

f. Adjust the Kintel 303B for an output level at the middle of the RANGE VOLTS switch setting (i.e., 0.375 volts). Note the Kintel 303B indication.

g. Adjust the LTPS-11A frequency to 100 Hz and increase its output level to obtain a galvanometer null.

h. Set the switch to setup B.

i. Adjust the MANUAL BALANCE COARSE and FINE controls to obtain a front panel meter indication of 0 on the BAL scale.

j. Depress the TRANSFER RESET pushbutton switch and note the digital voltmeter indication. The voltage accuracy should be with that listed in table 1-4.

k. Repeat the above procedure for each setting of the RANGE VOLTS switch, using the frequency ranges listed in table 1-4.

4-9. NON-DEFINITIVE CHECK. To perform a non-definitive minimum performance standards checks, proceed as directed in table 4-2.

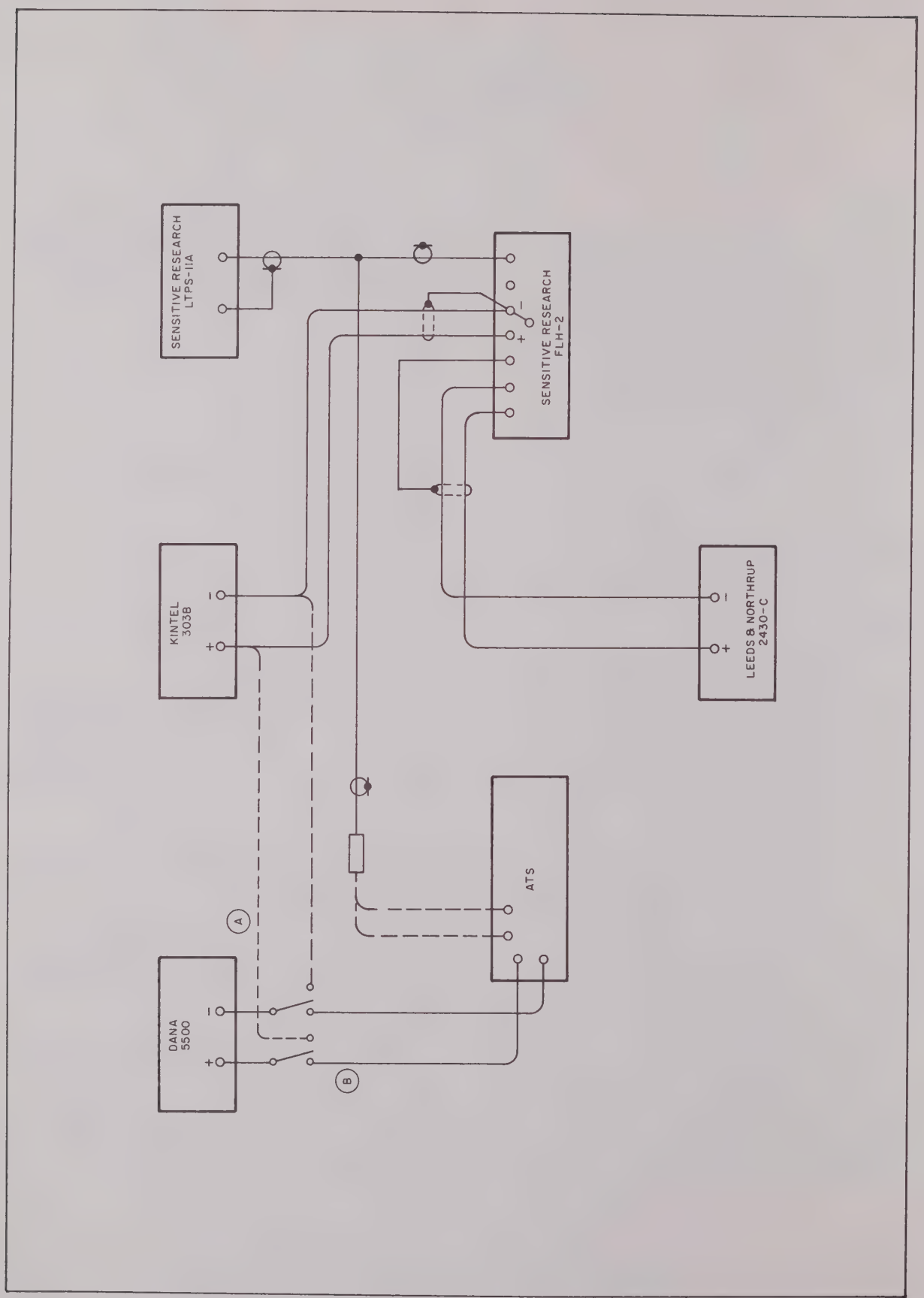


Figure 4-1. Equipment Setup for Definitive Minimum Performance Standards Checks

TABLE 4-2. MINIMUM PERFORMANCE STANDARDS CHECKS

Step	Purpose	Procedure	Acceptable Indication
1	To check transfer accuracy of manual balance mode.	a. Connect the equipment as shown in figure 4-2. Adjust the Kintel 303B for minimum output level.	
		b. Set the RANGE VOLTS switch to 0.25 TO 0.5, set the mode switch to MANUAL BALANCE and energize the ATS. Energize all auxiliary equipment and allow sufficient warmup time.	
		c. The AC indicator should be illuminated. If the DC indicator is illuminated, momentarily depress the TRANSFER-RESET pushbutton switch.	c. AC indicator is illuminated.
		d. Set the DPDT switch to position A. Increase the Kintel 303B output to 0.375 volts. Note the digital voltmeter indication.	
		e. Adjust the MANUAL BALANCE COARSE and FINE controls to obtain a front panel meter indication of 0 on the BAL scale.	e. BAL scale indication of 0 is obtained.
		f. Momentarily depress the TRANSFER-RESET pushbutton switch; the DC indicator should illuminate. Set the DPDT switch to position B and note the digital voltmeter indication.	f. Digital voltmeter should indicate within ±0.01% of that noted in step d.
		g. Momentarily depress the TRANSFER-RESET pushbutton switch; the AC indicator should illuminate.	g. AC indicator illuminates.
		h. Repeat steps d through g for the RANGE VOLTS switch settings and Kintel 303B output levels listed below:	h. Same as step f.
		RANGE VOLTS Switch Setting / Kintel 303B Output Level 0.5 TO 1 — 0.75 volts 1 TO 2 — 1.5 volts 2 TO 4 — 3 volts 4 TO 8 — 6 volts 8 TO 16 — 12 volts 16 TO 32 — 24 volts	
		i. Reduce the Kintel 303B output level to minimum and connect the signal to the AC INPUT 32 - 1000V connector.	
		j. Repeat steps d through g for the RANGE VOLTS switch settings and Kintel 303B output levels listed below:	j. Same as step f.

(Cont'd)

TABLE 4-2. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure	Acceptable Indication
		RANGE VOLTS Switch Setting / Kintel 303B Output Level 32 TO 64 — 48 volts 64 TO 125 — 96 volts 125 TO 250 — 190 volts 250 TO 500 — 375 volts 500 TO 1000 — 750 volts	
2	To check transfer accuracy in automatic transfer mode.	a. Connect the equipment as shown in figure 4-2. Adjust the Kintel 303B for minimum output level.	
		b. Set the RANGE VOLTS switch to 0.25 TO 0.5, set the mode switch to AUTO and energize the ATS. Energize all auxiliary equipment and allow warmup time.	
		c. The AC indicator should be illuminated. If the DC indicator is illuminated, momentarily depress the TRANSFER-RESET pushbutton switch.	c. AC indicator is illuminated.
		d. Set the DPDT switch to position A. Increase the Kintel 303B output level to 0.375 volts. Note the digital voltmeter indication.	
		e. After approximately 10 - 15 seconds, the DC indicator will illuminate. When this occurs, set the DPDT switch to position B and note the digital voltmeter indication.	e. Digital voltmeter should indicate within 0.015% of that noted in step d.
		f. Momentarily depress the TRANSFER-RESET pushbutton switch; the AC indicator should illuminate.	f. AC indicator illuminates.
		g. Repeat steps d through f for RANGE VOLTS switch settings and Kintel 303B output levels listed below: RANGE VOLTS Switch Setting / Kintel 303B Output Level 0.5 TO 1 — 0.75 volts 1 TO 2 — 1.5 volts 2 TO 4 — 3 volts 4 TO 8 — 6 volts 8 TO 16 — 12 volts 16 TO 32 — 24 volts	g. Same as e.
		h. Reduce the Kintel 303B output level to minimum and connect the signal to the AC INPUT 32 - 1000V connector.	
		i. Repeat steps d through f for RANGE VOLTS switch settings and Kintel 303B output levels listed below:	i. Same as step e.

(Cont'd)

TABLE 4-2. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure		Acceptable Indication
		RANGE VOLTS Switch Setting	Kintel 303B Output Level	
		32 TO 64	48 volts	
		64 TO 125	96 volts	
		125 TO 250	190 volts	
		250 TO 500	375 volts	
		500 TO 1000	750 volts	

4-10. OVERLOAD PROTECTION CHECK. To check the overload protection circuitry, proceed as follows.

a. With the ATS energized, set the RANGE VOLTS switch to 4 TO 8, set the mode switch to MANUAL TRANSFER, and depress TRANSFER RESET pushbutton switch so that the AC indicator is illuminated.

b. Connect a low-distortion a-c source (such as the SENSITIVE RESEARCH LTPS-11A), set for minimum output level at 1 kHz, to the AC INPUT 0.25 - 32V connector.

CAUTION

Do not exceed 12 vac.

c. Increase the a-c source output level until the overload protection circuitry is tripped (OVERLOAD PROTECTION indicator illuminated). Note a-c source level; it should be 10 volts ±10%.

d. If overload operation is satisfactory, adjust a-c source output to 11 volts and then momentarily depress the OVERLOAD PROTECTION PUSH TO RESET switch. The OVERLOAD PROTECTION indicator should remain illuminated after the switch is released.

e. Reduce the a-c source level to 9 volts and momentarily depress the OVERLOAD PROTECTION PUSH TO RESET switch. The OVERLOAD PROTECTION indicator should no longer be illuminated after the switch is released.

4-11. COMPONENT LOCATIONS.

4-12. The location of major assemblies and subassemblies are illustrated in figure 4-3 through 4-5.

4-13. POWER SUPPLY CHECKS.

4-14. Improper operation of the equipment may be due to a malfunction within one of the power supplies: main frame power +28VDC supply, and pc boards A4, A9, A10, A11 and A13. To ascertain that the required voltages are being developed, proceed as directed in the following steps:

a. Remove eight screws and the bottom plate from the ATS to gain access to terminal measurement points.

b. Couple the ATS to line power as described in Section II.

c. Measure the voltages present between the points specified in table 4-3. See figures 4-4 and 4-5 for the location of terminal measurement points.

d. Measure the +28vdc unregulated output of main frame power supply by connecting a vtvm between junction of A1R40 - A1C1, and chassis ground. A reading of between +24 and +30 volts should be obtained.

4-15. LOCATING TROUBLE WITHIN POWER SUPPLIES.

4-16. To localize a malfunction within one of the d-c power supply circuits, proceed as directed in table 4-3.

4-17. SETTING ± 15 VOLT SUPPLIES.

4-18. +15-Volt Supply. To set the output of the +15-volt power supply circuit A9, proceed as directed in the following steps:

a. Remove the top and bottom cover plates from the equipment and rest the unit on its side.

b. Remove A9 from its slot in the equipment and place the service extender board A14 in the slot normally occupied by A9. Insert A9 into the top connector of the service extender board.

c. Couple the ATS to line power as directed in Section II.

d. Connect a digital voltmeter between connector J8-1 and chassis ground.

e. While observing the digital voltmeter display, carefully adjust trimmer potentiometer A9R7 for 15±.015 volts.

CAUTION

If output voltage exceeds 18 volts, do not attempt to adjust. Remove circuit board immediately. The excess voltage may damage other circuits of the equipment. Refer to Power Supply Trouble Localization Procedure table 4-4.

f. Replace A9 in its proper slot within the unit.

4-19. Setting -15 Volt Supply. To set the output voltage of the -15 volt power supply board, follow the same procedure given above but work with A10 instead.

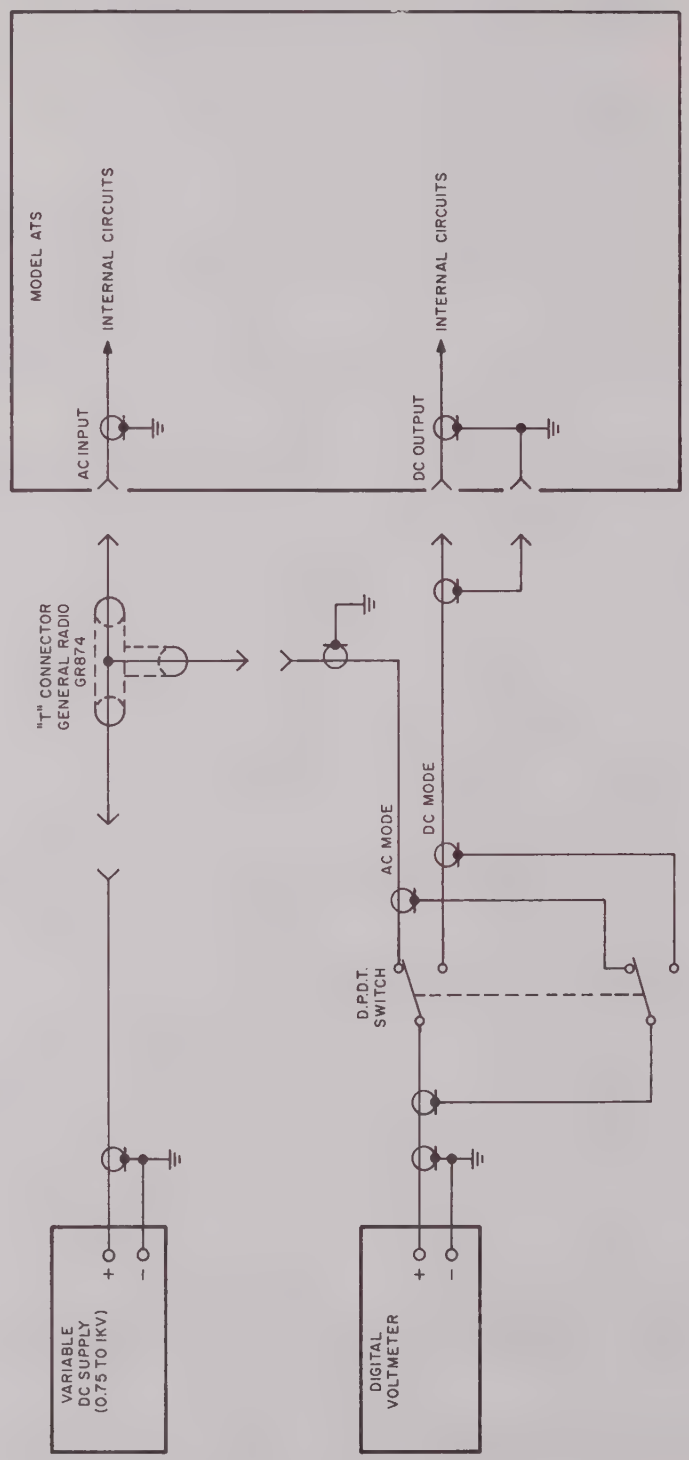


Figure 4-2. Equipment Setup for Non-Definitive Minimum Performance Standards Checks

TABLE 4-2. MINIMUM PERFORMANCE STANDARDS CHECKS (Cont'd)

Step	Purpose	Procedure		Acceptable Indication
		RANGE VOLTS Switch Setting	Kintel 303B Output Level	
		32 TO 64	48 volts	
		64 TO 125	96 volts	
		125 TO 250	190 volts	
		250 TO 500	375 volts	
		500 TO 1000	750 volts	

4-10. OVERLOAD PROTECTION CHECK. To check the overload protection circuitry, proceed as follows.

a. With the ATS energized, set the RANGE VOLTS switch to 4 TO 8, set the mode switch to MANUAL TRANSFER, and depress TRANSFER RESET pushbutton switch so that the AC indicator is illuminated.

b. Connect a low-distortion a-c source (such as the SENSITIVE RESEARCH LTPS-11A), set for minimum output level at 1 kHz, to the AC INPUT 0.25 - 32V connector.

CAUTION

Do not exceed 12 vac.

c. Increase the a-c source output level until the overload protection circuitry is tripped (OVERLOAD PROTECTION indicator illuminated). Note a-c source level; it should be 10 volts ±10%.

d. If overload operation is satisfactory, adjust a-c source output to 11 volts and then momentarily depress the OVERLOAD PROTECTION PUSH TO RESET switch. The OVERLOAD PROTECTION indicator should remain illuminated after the switch is released.

e. Reduce the a-c source level to 9 volts and momentarily depress the OVERLOAD PROTECTION PUSH TO RESET switch. The OVERLOAD PROTECTION indicator should no longer be illuminated after the switch is released.

4-11. COMPONENT LOCATIONS.

4-12. The location of major assemblies and subassemblies are illustrated in figure 4-3 through 4-5.

4-13. POWER SUPPLY CHECKS.

4-14. Improper operation of the equipment may be due to a malfunction within one of the power supplies: main frame power +28VDC supply, and pc boards A4, A9, A10, A11 and A13. To ascertain that the required voltages are being developed, proceed as directed in the following steps:

a. Remove eight screws and the bottom plate from the ATS to gain access to terminal measurement points.

b. Couple the ATS to line power as described in Section II.

c. Measure the voltages present between the points specified in table 4-3. See figures 4-4 and 4-5 for the location of terminal measurement points.

d. Measure the +28vdc unregulated output of main frame power supply by connecting a vtvm between junction of A1R40 - A1C1, and chassis ground. A reading of between +24 and +30 volts should be obtained.

4-15. LOCATING TROUBLE WITHIN POWER SUPPLIES.

4-16. To localize a malfunction within one of the d-c power supply circuits, proceed as directed in table 4-3.

4-17. SETTING ± 15 VOLT SUPPLIES.

4-18. +15-Volt Supply. To set the output of the +15-volt power supply circuit A9, proceed as directed in the following steps:

a. Remove the top and bottom cover plates from the equipment and rest the unit on its side.

b. Remove A9 from its slot in the equipment and place the service extender board A14 in the slot normally occupied by A9. Insert A9 into the top connector of the service extender board.

c. Couple the ATS to line power as directed in Section II.

d. Connect a digital voltmeter between connector J8-1 and chassis ground.

e. While observing the digital voltmeter display, carefully adjust trimmer potentiometer A9R7 for 15±.015 volts.

CAUTION

If output voltage exceeds 18 volts, do not attempt to adjust. Remove circuit board immediately. The excess voltage may damage other circuits of the equipment. Refer to Power Supply Trouble Localization Procedure table 4-4.

f. Replace A9 in its proper slot within the unit.

4-19. Setting -15 Volt Supply. To set the output voltage of the -15 volt power supply board, follow the same procedure given above but work with A10 instead.

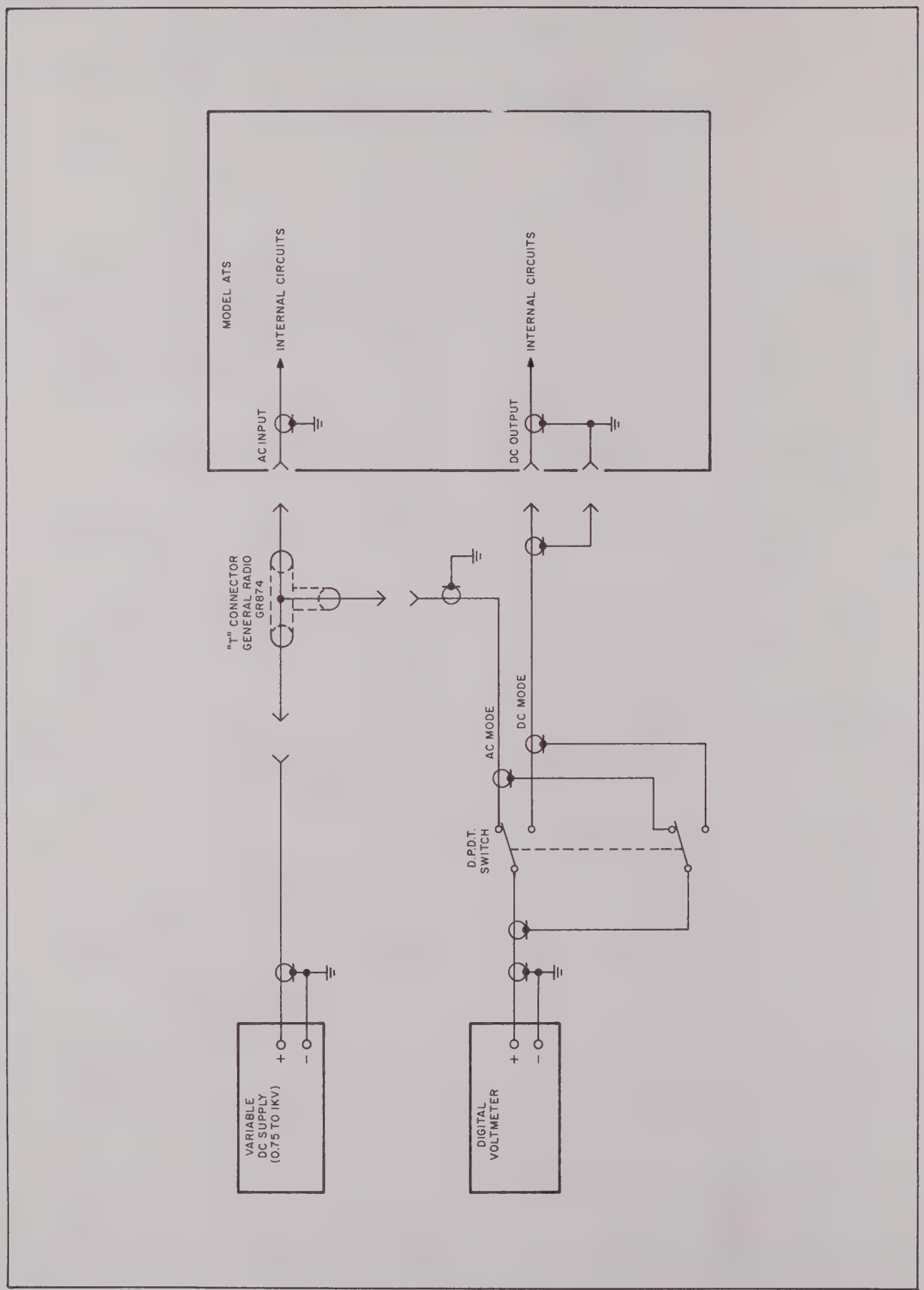


Figure 4-2. Equipment Setup for Non-Definitive Minimum Performance Standards Checks

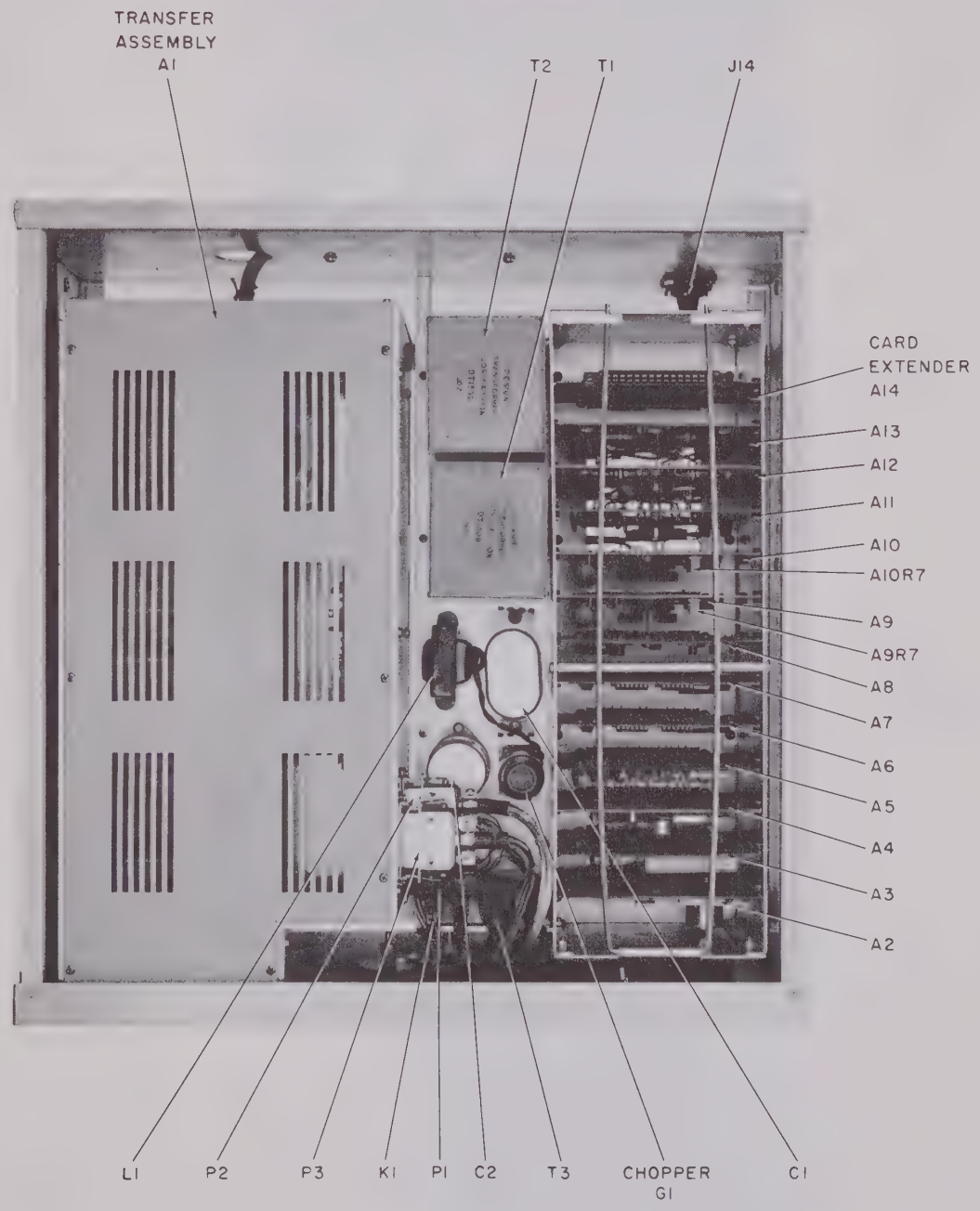


Figure 4-3. ATS, Top View

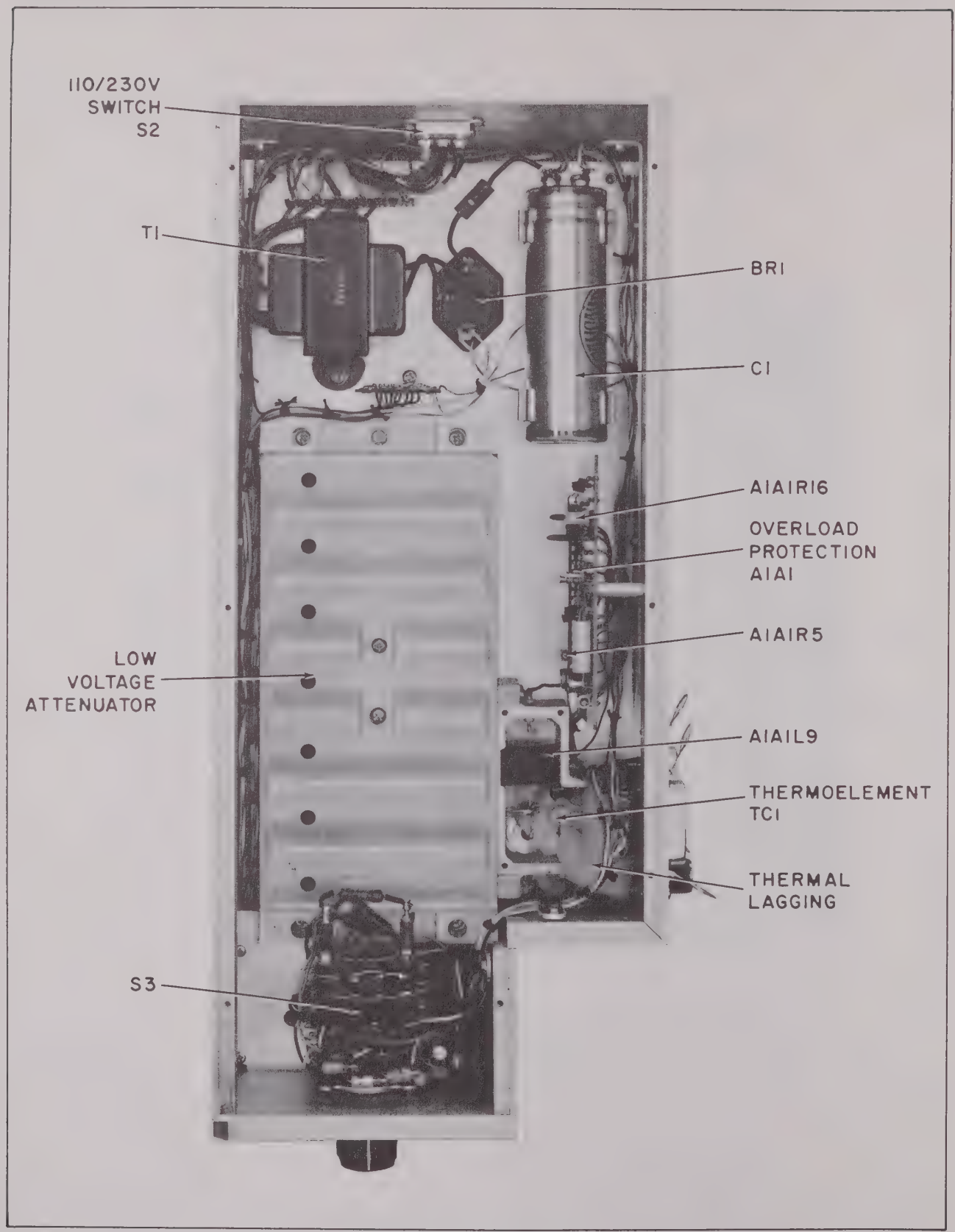


Figure 4-4. Transfer Assembly A1, Top View

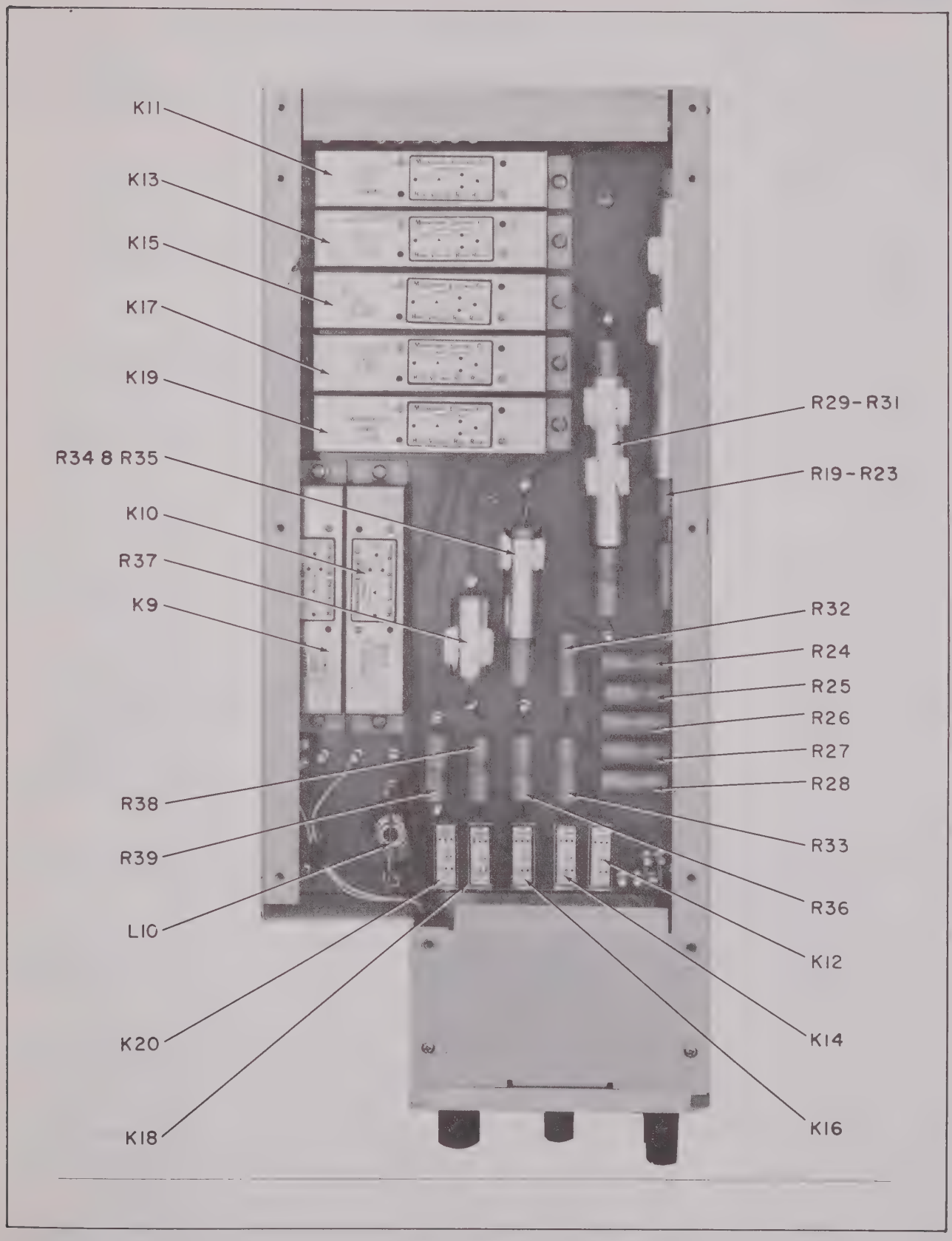


Figure 4-5. Transfer Assembly A1, Bottom View

TABLE 4-3. POWER SUPPLY CHECK

Connect Positive VTVM Lead To	Connect Common VTVM Lead to	Normal Indication
J8-1	Chassis	+15v ±0.015v
Chassis	J9-6	+15v ±0.015v
J10-14	Chassis	+3.6v ±0.15v
J10-11	Chassis	+3.9v ±0.15v
J3-5	Chassis	+43v ±3.0v
J12-1	Chassis	+1500v ±150v

TABLE 4-4. POWER SUPPLY TROUBLE LOCALIZATION PROCEDURE

Step	Instructions	Normal Indication	If Indication Is Normal	If Indication Is Abnormal
1	Couple the ATS to line power as described in Section II.	POWER PUSH pushbutton illuminates.	Proceed to step 2.	Check lamp A1DS1 inside pushbutton. Check 0.5A delay fuse A1F1. Check a-c line cord. Check POWER PUSH switch A1S1 and associated wiring. Check filter A1C1 and A1R40. Check bridge rectifier unit A1BR8. Check power transformer T1 and line switch S2.
2	Measure the voltage developed between junction of resistor A1R40 - capacitor A1C1 and chassis.	Reading should be between +24 and +33 volts d-c.	Proceed to step 3.	Follow procedures given above in step 1.
3	Measure the voltage developed between connector J8-1 and chassis.	Reading should be between +14.98 and +15.01 volts d-c.	Proceed to step 4.	Check adjustment of trim potentiometer A9R7, see paragraph 4-18. Check +15 volt power supply board, diodes A9CR1 and A9CR2. Check transistor A9Q1 through A9Q4. Check diodes A9CR3 and A9CR4.

(Cont'd)

TABLE 4-4. POWER SUPPLY TROUBLE LOCALIZATION PROCEDURE (Cont'd)

Step	Instructions	Normal Indication	If Indication Is Normal	If Indication Is Abnormal
				Check potentiometer A9R7 and all other fixed resistors, and capacitors A9C1 and A9C2.
4	Measure the voltage developed between connector J9-1 and chassis.	Reading should be between -14.98 and 15.01 volts d-c.	Proceed to step 5.	Follow procedures given above in step 3. Board A9 and A10 are identical except for circuit polarity connections.
5	Measure the voltage developed between connector J3-5 and chassis.	Reading should be between +40 and +46 volts d-c.	Proceed to step 6.	Check Low Voltage Amplifier board, diodes A4CR3 and A4CR6. Check filter resistor A4R12 and capacitor A4C5. Check Zener diode A4CR7. Check secondary winding (terminals 13 and 14) of power transformer T1.
6	Measure the voltage developed between connector J10-14 and chassis.	Reading should be between +3.45 and 3.75 volts d-c.	Proceed to step 7.	Check voltages developed by both 15-volt Power Supply boards A9 and A10 before troubleshooting this board. Check diodes A11CR2 through A11CR7. Check transistors A11Q2 through A11Q4 and Q1 mounted on main frame. Check capacitor C2 mounted on main frame. Check resistors A11R4 through A11R8.
7	Measure the voltage developed between connector J10-11 and chassis.	Reading should be between 3.75 and 4.05 volts d-c.	Proceed to step 8.	Check voltage developed by both 15-Volt Power Supply boards A9 and A10 (steps 3 and 4) before troubleshooting this board.

TABLE 4-4. POWER SUPPLY TROUBLE LOCALIZATION PROCEDURE (Cont'd)

Step	Instructions	Normal Indication	If Indication Is Normal	If Indication Is Abnormal
				Check diode A11CR1. Check transistor A11Q1 and operational amplifier A11MC1. Check capacitor C3 mounted on main frame.
8	Measure the voltage developed between connector J12-1 and chassis.	Reading should be between +1350 and +1650 volts.		Check High Voltage Amplifier board, diodes A13CR2 through A13CR5. Check filter capacitor C1 and choke L1 both mounted on main frame. Check secondary winding on power transforner T2 (terminals 5 and 6), mounted on main frame.

4-20. TROUBLE LOCALIZATION.

4-21. A symptomatic trouble localization guide (see table 4-5) is provided to enable the technician to isolate a malfunction to an individual or group of assemblies. Once the malfunction has been localized, the operator can effect the necessary repairs through the use of the appropriate voltage measurements provided in paragraph 4-26.

4-22. THERMOELEMENT REPLACEMENT.

4-23. If thermoelement A1TC1 is found to be defective, it should be replaced as follows:

a. Remove the top cover from the equipment.

b. Remove the seven screws which secure the top plate to the transfer assembly. Remove the top plate.

c. Remove the four screws which secure the cover plate to the thermoelement housing. Remove the cover plate and thermal lagging.

d. Observe the orientation and connections of the original thermoelement before removing it from its mounting. Thermoelements are color coded to insure proper polarity when they are replaced. The replacement item will have a red or black dot identifying one of the lead wires. In either case, the red dot lead is to be connected to the terminal with the red wire, the black dot lead to the terminal with the black wire.

e. Remove the original thermoelement and install the replacement using as little heat as possible in the operation.

Note

If a factory-supplied replacement thermoelement is installed, the accuracy of the ATS will not be impaired and previous calibration data will still be valid.

f. Replace the thermal lagging, thermoelement housing cover plate, transfer assembly top plate, and ATS top cover plate.

4-24. OVERLOAD PROTECTION BOARD A1A1, CALIBRATION.

4-25. To set the overload protection circuitry, proceed as directed in the following steps.

a. With mode switch set to AUTO, no signal coupled to either AC INPUT connector and the AC indicator illuminated, connect an ungrounded VOM between A1A1TP1 and A1A1TP2.

b. Adjust A1A1R5 to obtain a VOM indication of 0 volts, (using lowest voltage range).

c. Set the RANGE VOLTS switch to 8 and 16 and the mode switch to MANUAL BALANCE.

d. Momentarily depress the TRANSFER RESET switch to illuminate the DC indicator.

e. Adjust the MANUAL BALANCE COARSE and FINE controls to obtain a front panel meter DC OUTPUT VOLTS scale indication of 1.0.

f. Couple a low-distortion a-c source (such as the SENSITIVE RESEARCH LTPS-11A) set to 10 volts rms at 1 kHz, to the AC INPUT 0.5 - 32V connector.

g. Depress the TRANSFER RESET switch; the AC indicator should illuminate.

h. Adjust the a-c source output level to obtain a front panel meter indication of 0 on the BAL scale.

i. Set the RANGE VOLTS switch to 4 TO 8.

Note

The overload protection circuitry may trip.

j. Adjust A1A1R16 (resetting the OVERLOAD PROTECTION PUSH TO RESET switch as required) until the overload protection circuitry just barely trips.

4-26. VOLTAGE MEASUREMENTS.

4-27. Voltage measurements for all the assemblies referenced in the troubleshooting procedures are contained in tables 4-6 through 4-17. Note that all measurements were made with a vtvm with respect to equipment ground.

TABLE 4-5. TROUBLE LOCALIZATION

Symptom	Probable cause of trouble
1. Overload protection system does not function.	Defective Overload Protection circuit board A1A1.
2. Overload protection system will not reset.	Defective thermoelement A1TC1.
3. A null cannot be obtained on a given RANGE VOLTS setting.	Defective attenuator circuit. Return equipment to manufacturer.
4. A d-c output cannot be obtained on any RANGE VOLTS setting at low end (32V or less) but equipment works normally at high end (32V or more).	Defective Low Voltage Ampl circuit board A4.
5. A d-c output cannot be obtained on any RANGE VOLTS setting at high end (32V or more) but equipment works normally at low end (32V or less).	Defective High Voltage Ampl circuit boards A12 and/or A13.
6. A null cannot be obtained on any range in AUTO mode, normal operation in MANUAL BALANCE.	Defective circuit board: Clock and Gating A8 Counter A6 and/or A7 Ladder & Buffer Ampl A5 +3.6 and +3.9 Volt Power Supplies
7. A null cannot be obtained in MANUAL BALANCE mode, normal operation in AUTO and MANUAL TRANSFER.	Defect in COARSE and FINE adjustment circuit.
8. A null cannot be obtained in any mode.	Defective circuit board: Chopper Ampl A2 DC Ampl and Filter A3
9. A null is obtained but no dc output voltage is developed.	Defective DC Ampl and Filter circuit board A3.
10. Equipment will not transfer from AC to DC status in AUTO mode, normal operation in MANUAL BALANCE and MANUAL TRANSFER.	Defective Low Voltage Ampl circuit board A4.
11. Equipment will not transfer in any mode.	Defective transfer relay K1 circuit.

TABLE 4-6. VOLTAGE MEASUREMENTS, OVERLOAD PROTECTION BOARD A1A1

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1(FET)	2N2386	+0.1(S)	0.0(G)	-11.0(D)
Q2(FET)	2N2386	+0.1(S)	0.0(G)	-11.0(D)
Q3	2N3904	-11.8	-11.0	+1.7
Q4	2N3904	-11.8	-11.0	+1.7
Q5	2N3904	+4.3	+1.2	+15.0
Q6	2N3904	+4.3	+4.9	+15.0
Q7	2N3906	+15.0	+15.0	-1.5
Q8(SER)	2N2323	+24(A)	-0.6(G)	0.0(K)
Q9	2N1711	0.0	+0.8	+0.3
Q10	2N3904	+0.1	+0.1	+28
Q11	2N3904	0.0	+0.7	+0.1

Note: All voltages measured with ATS in the a-c balance state, overload circuitry operative and no signal applied to ATS.

TABLE 4-7. VOLTAGE MEASUREMENTS, CHOPPER AMPLIFIER A2

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3391A	-0.5	0.0	+2.0
Q2	2N3391A	+1.4	+2.0	+4.3
Q3	2N3391A	+3.7	+4.3	+15.0
Q4	2N1306	0.0	-7.9	0.0
Q5	2N1306	0.0	-7.9	0.0

Note: All voltages measured with ATS in MANUAL BALANCE mode, d-c output state and no signal applied.

TABLE 4-8. VOLTAGE MEASUREMENTS, DC AMPLIFIER AND FILTER A3

Reference Symbol Number	Type	Terminal No.							
		1	2	3	4	5	6	7	8
MC1	uA709C	+10	0.0	0.0	-15.0	-14.3	0.0	+15.0	+10
MC2	uA709C	+10	0.0	0.0	-15.0	-14.3	-5.4	+15.0	+10

Note: All voltages measured with ATS in MANUAL BALANCE mode, d-c output state and no signal applied.

TABLE 4-9. VOLTAGE MEASUREMENTS, LOW VOLTAGE AMPLIFIER A4

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3904	0.0	+0.6	+10.0
Q2	2N3906	+10.5	+10.0	+0.8
Q3	2N3904	0.0	+0.6	+25.1
Q4	2N3904	+24.5	+25.1	+43.0
Q5(SCR)	2N2323	0.0(A)	+0.4(G)	0.0(K)
Q6(UJ)	2N4870	0.0	+0.4(B_1)	+14.0(B_2)
Q7	2N3904	0.0	+0.7	0.0
Q8	2N3904	0.0	+0.1	0.0
Q9	2N3904	0.0	+0.1	0.0

Note: All voltages measured in d-c output state with RANGE VOLTS switch set to 8 TO 16 and MANUAL BALANCE controls adjusted for 15.00 volt output.

TABLE 4-10. VOLTAGE MEASUREMENTS, LADDER AND BUFFER AMPLIFIER A5

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage		Nominal Base Voltage		Nominal Collector Voltage			
Q1	2N3904	+3.3		+3.9		+15.0			
		Pin Number							
		1	2	3	4	5	6	7	8
MC4	μA709C	+10.0	+3.3	+3.3	-15.0	-14.4	+4.0	+15.0	+10.0

Note: All voltages measured in d-c output state with RANGE VOLTS switch set to 8 TO 16 and MANUAL BALANCE controls adjusted for 15.00 volt output.

TABLE 4-11. VOLTAGE MEASUREMENTS, CLOCK AND GATING BOARD A8

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3904	0.0	0.0	+1.4
Q2	2N3904	-15.0	-15.0	+1.4
Q3	2N3904	0.0	0.0	+1.4
Q4	2N3904	0.0	+0.3	+1.2
Q5	2N3906	0.0	0.0	-15
Q6	2N4870	+5.7	0.56(B_1)	+14.0(B_2)

Note: All voltages measured in d-c output state with RANGE VOLTS switch set to 8 TO 16 and MANUAL BALANCE controls adjusted for 15.00 volt output.

TABLE 4-12. VOLTAGE MEASUREMENTS +15-VOLT SUPPLY A9

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3904	+15.7	+16.3	+24.0
Q2	2N3904	+5.6	+6.2	+15.0
Q3	2N3904	+5.6	+6.2	+16.3
Q4	40326	+15.0	+15.7	+24.0

Note: All voltages measured in d-c output state with RANGE VOLTS switch set to 8 TO 16 and MANUAL BALANCE controls adjusted for 15.00 volt output.

TABLE 4-13. VOLTAGE MEASUREMENTS, -15 VOLT SUPPLY A10

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N3904	+0.65	+1.27	+9.5
Q2	2N3904	-9.4	-8.8	0.0
Q3	2N3904	-9.4	-8.8	+1.3
Q4	40326	0.0	+0.65	+9.5

Note: All voltages measured in d-c output state with RANGE VOLTS switch set to 8 TO 16 and MANUAL BALANCE controls adjusted for 15.00 volt output.

TABLE 4-14. VOLTAGE MEASUREMENTS, LOW VOLTAGE SUPPLY A11

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage			Nominal Base Voltage			Nominal Collector Voltage	
Q1	40326	+3.9			+4.5			+8.1	
Q2	40326	+4.3			+5.0			+7.5	
Q3	2N3904	+5.0			+5.6			+7.5	
Q4	2N3904	0.0			+0.6			+5.6	
		Pin Number							
		1	2	3	4	5	6	7	8
MC1	uA709C	+10	0	0	-15.0	-14.4	+4.5	+15.0	+10
Q1 on Chassis	2N4921	+3.6			+4.5			+7.5	

Note: All voltages measured in d-c output state with RANGE VOLTS switch set to 8 TO 16 and MANUAL BALANCE controls adjusted for 15.00 volt output.

TABLE 4-15. VOLTAGE MEASUREMENTS, HIGH VOLTAGE AMPLIFIER A12

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	40327	0	+0.562	+92.7
Q2	40327	+92.7	+92.2	+192
Q3	40327	+192	+189	+293
Q4	40327	+293	+287	+396
Q5	40327	+396	+388	+500
Q6	40327	+500	+492	+607
Q7	40327	+607	+601	+716
Q8	2N3906	+1.345	+0.699	+0.566
Q9	2N3904	0	+0.664	+0.701

Note: All voltages measured in d-c output state with RANGE VOLTS switch set to 64 TO 125 and MANUAL BALANCE controls adjusted for 115 volt output.

TABLE 4-16. VOLTAGE MEASUREMENTS, HIGH VOLTAGE AMPLIFIER A13

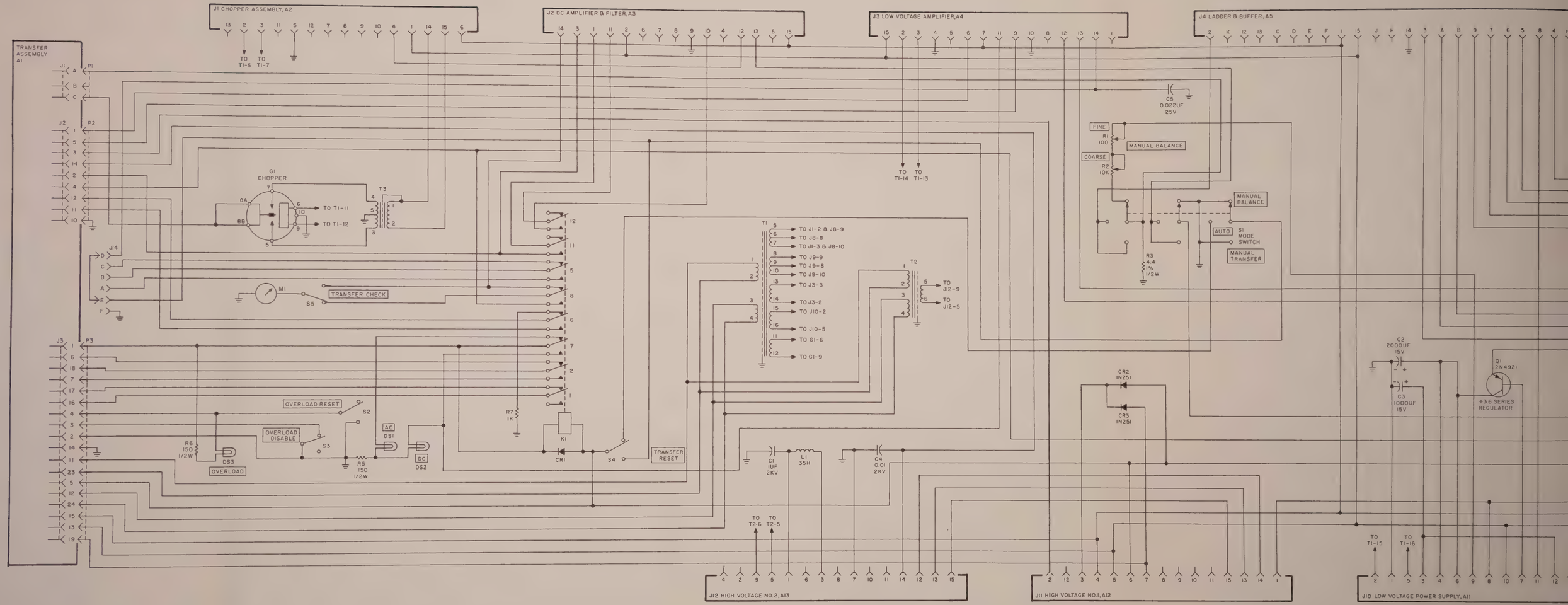
Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	40327	+1275	+1272	+1383
Q2	40327	+1172	+1163	+1275
Q3	40327	+1075	+1063	+1172
Q4	40327	+978	+968	+1075
Q5	40327	+885	+878	+978
Q6	40327	+798	+795	+885
Q7	40327	+716	+716	+798

Note: All voltages measured in d-c output state with RANGE VOLTS switch set to 64 TO 125 and MANUAL BALANCE controls adjusted for 115 volt output.

TABLE 4-17. VOLTAGE MEASUREMENTS, CHASSIS ASSEMBLY

Reference Symbol Number	Transistor Type	Nominal Emitter Voltage	Nominal Base Voltage	Nominal Collector Voltage
Q1	2N4921	+3.6	+4.5	+7.5

SECTION V
SCHEMATIC DIAGRAMS


J1 CHOPPER ASSEMBLY, A2
J2 DC AMPLIFIER & FILTER, A3
J3 LOW VOLTAGE AMPLIFIER, A4
J4 LADDER & BUFFER, A5
TRANSFER ASSEMBLY A1
J1
P1
J2
P2
J3
P3
J14
G1 CHOPPER
T3
T1
T2
M1
S5
TRANSFER CHECK
OVERLOAD RESET
S2
OVERLOAD DISABLE
S3
R6 150 1/2W
DS3
OVERLOAD
R5 150 1/2W
AC
DS1
DC
DS2
R7 1K
K1
CR1
S4
TRANSFER RESET
C1 1UF 2KV
L1 35H
C4 0.01 2KV
C5 0.022UF 25V
FINE
R1 100
MANUAL BALANCE
COARSE
R2 10K
MANUAL BALANCE
AUTO
S1 MODE SWITCH
MANUAL TRANSFER
R3 4.4 1% 1/2W
CR2 IN251
CR3 IN251
C2 2000UF 15V
C3 1000UF 15V
Q1 2N4921
+36 SERIES REGULATOR
TO T1-5
TO T1-7
TO T1-14
TO T1-13
TO T1-11
TO T1-12
TO J1-2 & J8-9
TO J8-8
TO J1-3 & J8-10
TO J9-9
TO J9-8
TO J9-10
TO J3-3
TO J3-2
TO J10-2
TO J10-5
TO G1-6
TO G1-9
TO J12-9
TO J12-5
TO T2-6
TO T2-5
TO T1-15
TO T1-16
J12 HIGH VOLTAGE NO.2, A13
J11 HIGH VOLTAGE NO.1, A12
J10 LOW VOLTAGE POWER SUPPLY, A11

108-0696 (10)

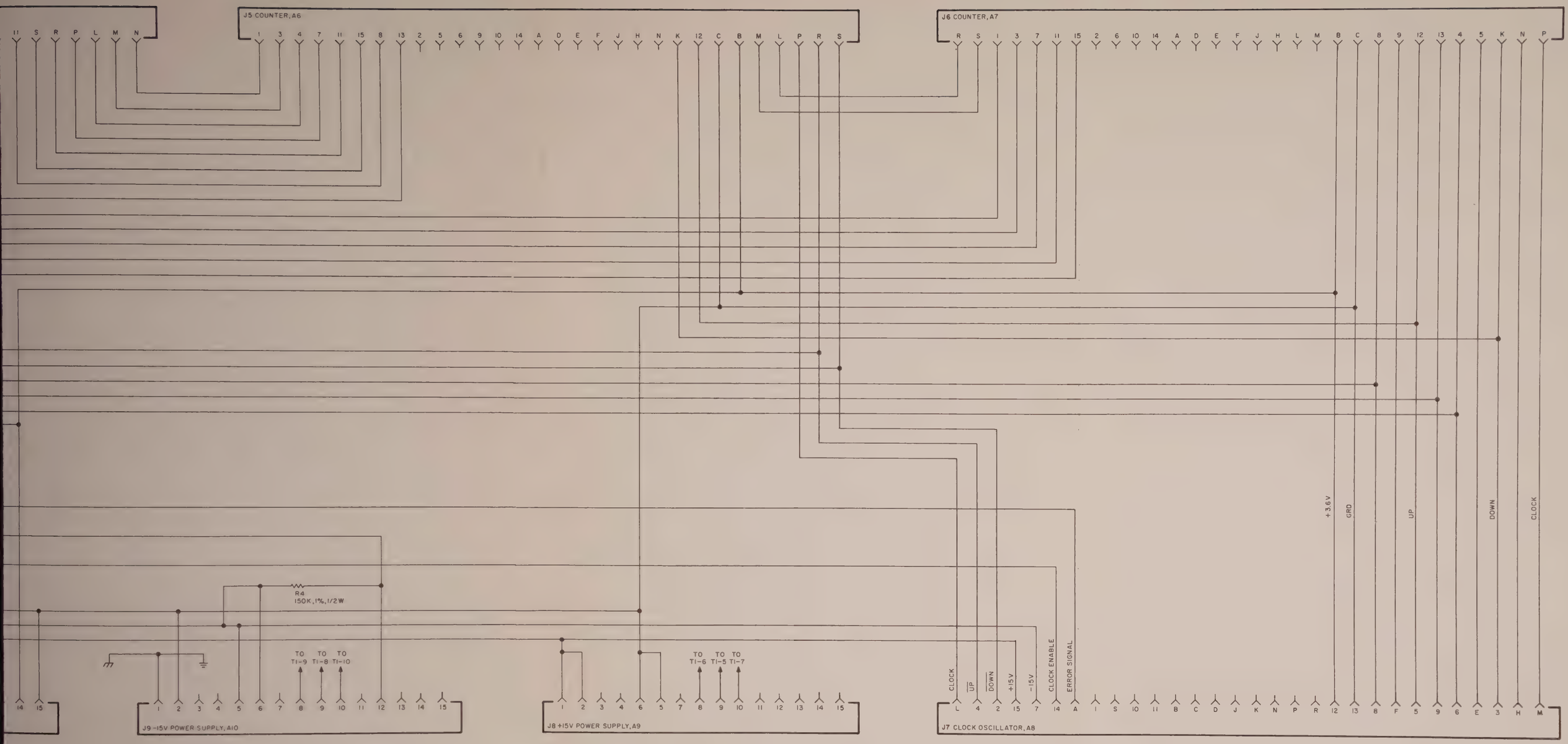
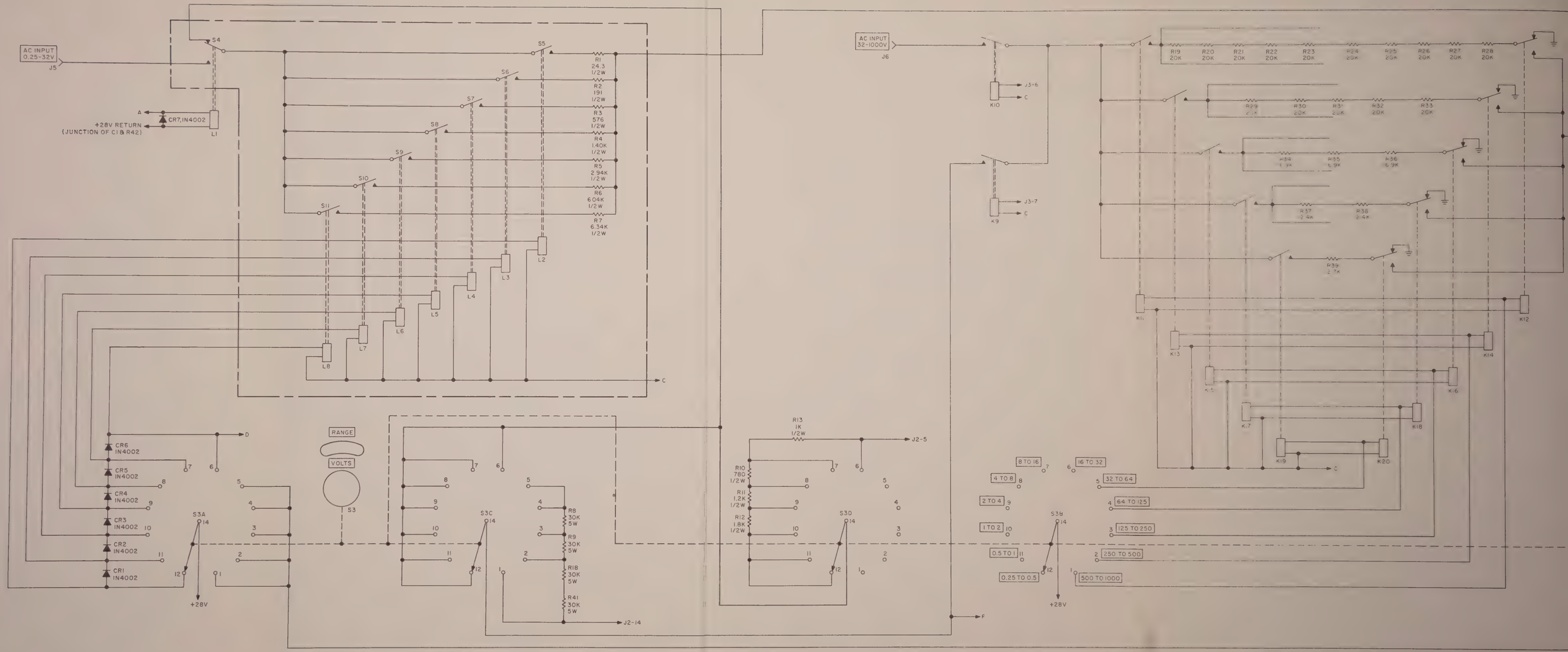

J5 COUNTER, A6
11 S R P L M N
1 3 4 7 11 15 8 13 2 5 6 9 10 14 A D E F J H N K 12 C B M L P R S
J6 COUNTER, A7
R S 1 3 7 11 15 2 6 10 14 A D E F J H L M B C 8 9 12 13 4 5 K N P
R4
150K, 1%, 1/2W
TO TI-9
TO TI-8
TO TI-10
14 15
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
J9 -15V POWER SUPPLY, A10
TO TI-6
TO TI-5
TO TI-7
1 2 3 4 6 5 7 8 9 10 11 12 13 14 15
J8 +15V POWER SUPPLY, A9
CLOCK
UP
DOWN
+15V
-15V
CLOCK ENABLE
ERROR SIGNAL
L 4 2 15 7 14 A 1 S 10 11 B C D J K N P R 12 13 8 F 5 9 6 E 3 H M
J7 CLOCK OSCILLATOR, A8
+3.6V
GRD
UP
DOWN
CLOCK

Figure 5-1. Interconnecting Cabling Diagram


AC INPUT 0.25-32V
J5
S4
S5
S6
S7
S8
S9
S10
S11
R1 24.3 1/2W
R2 191 1/2W
R3 576 1/2W
R4 1.40K 1/2W
R5 2.94K 1/2W
R6 6.04K 1/2W
R7 6.34K 1/2W
A
CR7,IN4002
+28V RETURN (JUNCTION OF C1 & R42)
L1
L2
L3
L4
L5
L6
L7
L8
C
CR6 IN4002
CR5 IN4002
CR4 IN4002
CR3 IN4002
CR2 IN4002
CR1 IN4002
D
RANGE
VOLTS
S3
S3A
S3C
S3D
S3B
+28V
R8 30K 5W
R9 30K 5W
R18 30K 5W
R41 30K 5W
J2-14
R13 1K 1/2W
R10 780 1/2W
R11 1.2K 1/2W
R12 1.8K 1/2W
J2-5
AC INPUT 32-1000V
J6
K10
K9
J3-6
J3-7
R19 20K
R20 20K
R21 20K
R22 20K
R23 20K
R24 20K
R25 20K
R26 20K
R27 20K
R28 20K
R29 20K
R30 20K
R31 20K
R32 20K
R33 20K
R34 9.9K
R35 9.9K
R36 9.9K
R37 2.4K
R38 2.4K
R39 2.7K
K11
K12
K13
K14
K15
K16
K17
K18
K19
K20
8 TO 16
16 TO 32
4 TO 8
32 TO 64
2 TO 4
64 TO 125
1 TO 2
125 TO 250
0.5 TO 1
250 TO 500
0.25 TO 0.5
500 TO 1000
F

106-0660 30

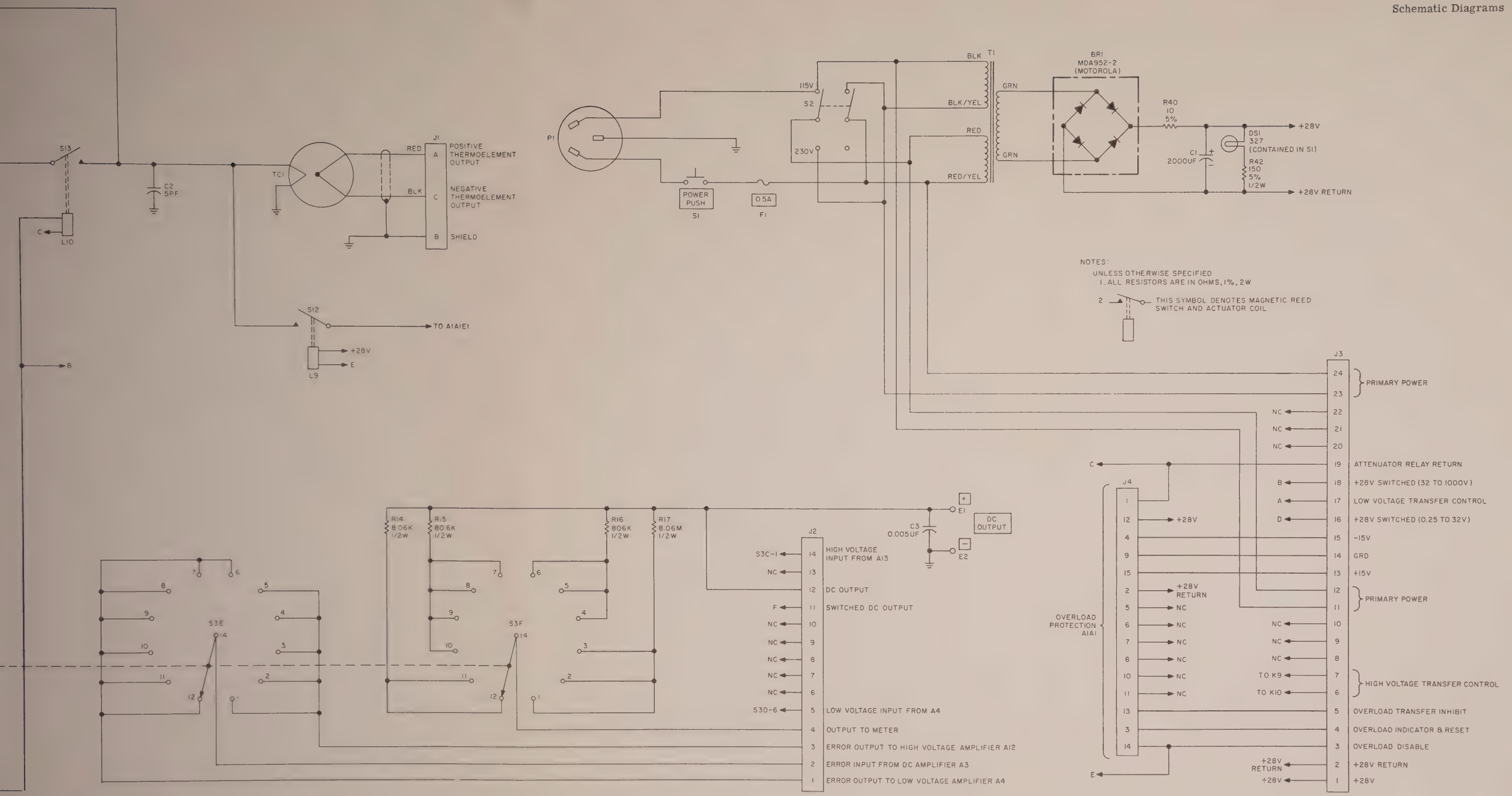


Figure 5-2. Transfer Assembly A1, Schematic Diagram

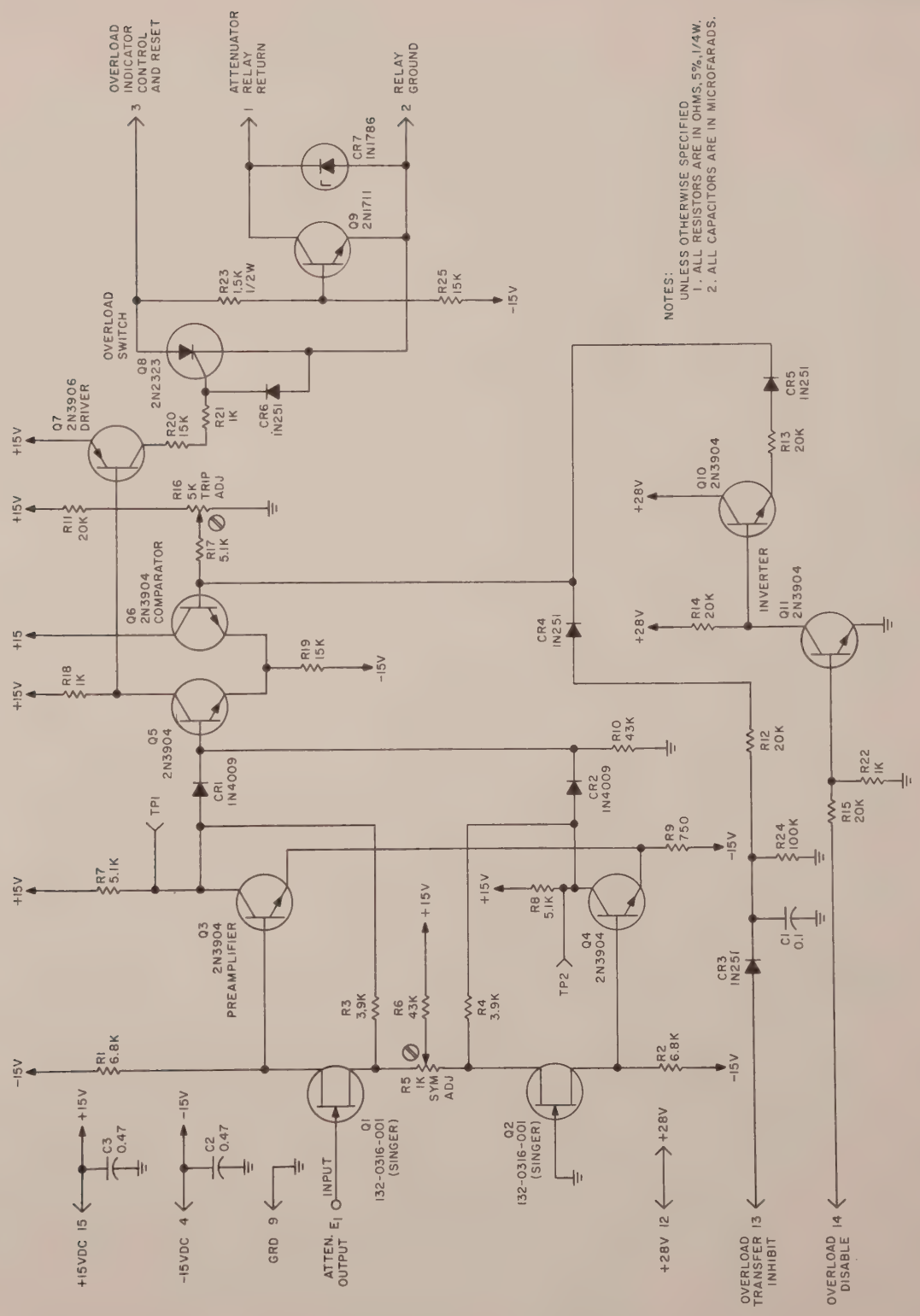
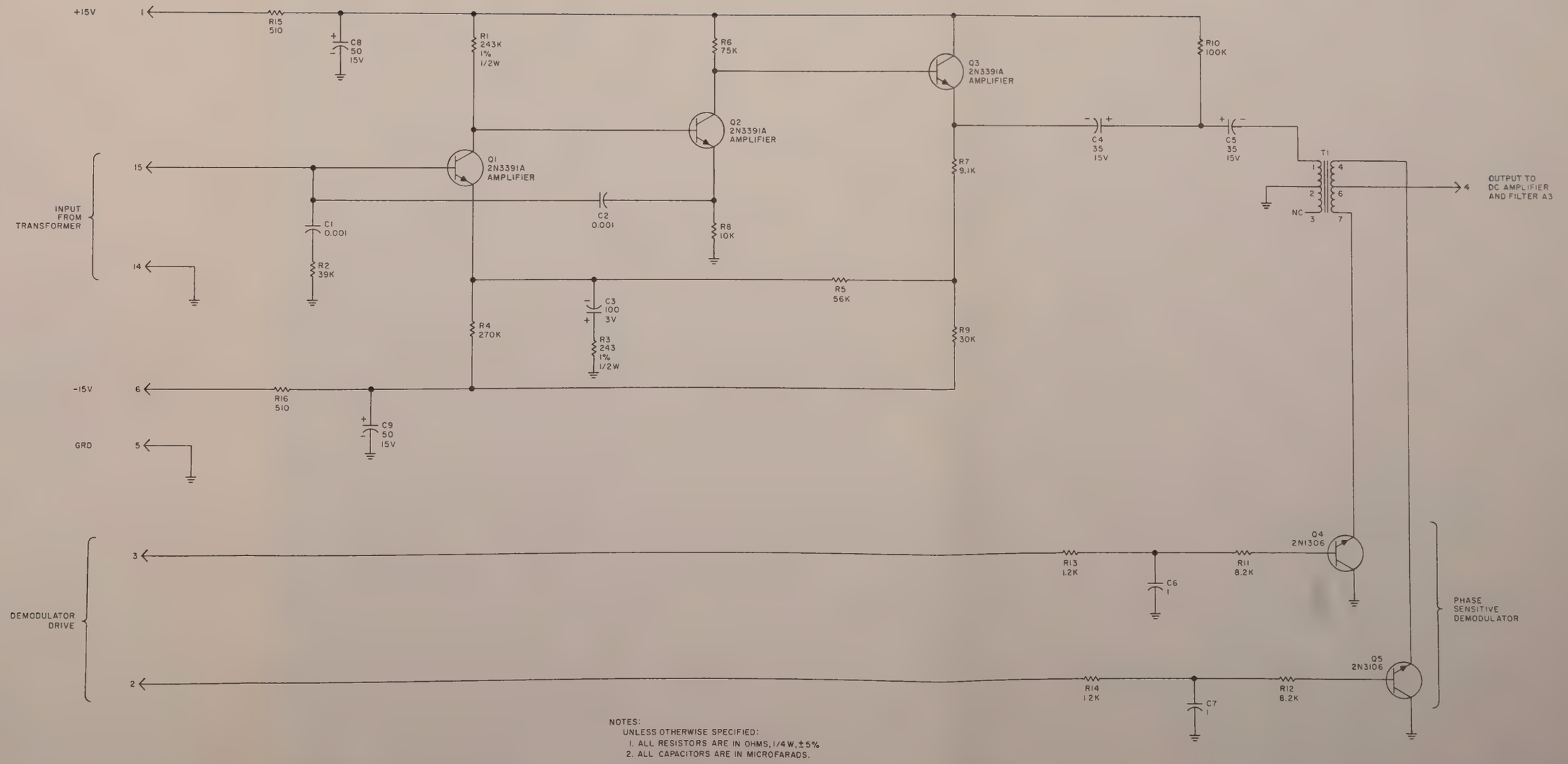


Figure 5-3. Overload Protection Board A1A1, Schematic Diagram

106-0558 00



NOTES:
UNLESS OTHERWISE SPECIFIED:
1. ALL RESISTORS ARE IN OHMS, 1/4W, ±5%
2. ALL CAPACITORS ARE IN MICROFARADS.

Figure 5-4. Chopper Amplifier A2, Schematic Diagram

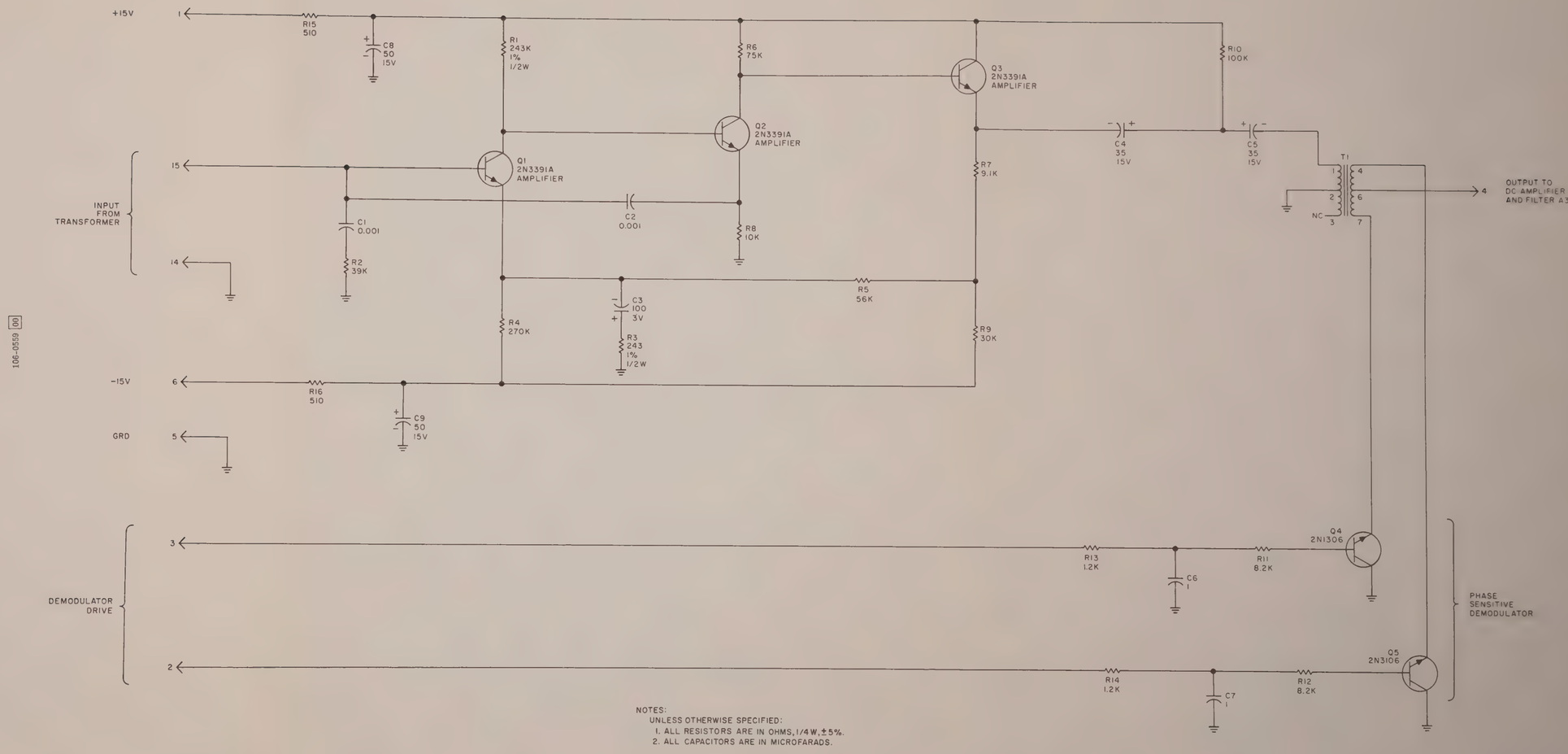


Figure 5-4. Chopper Amplifier A2, Schematic Diagram

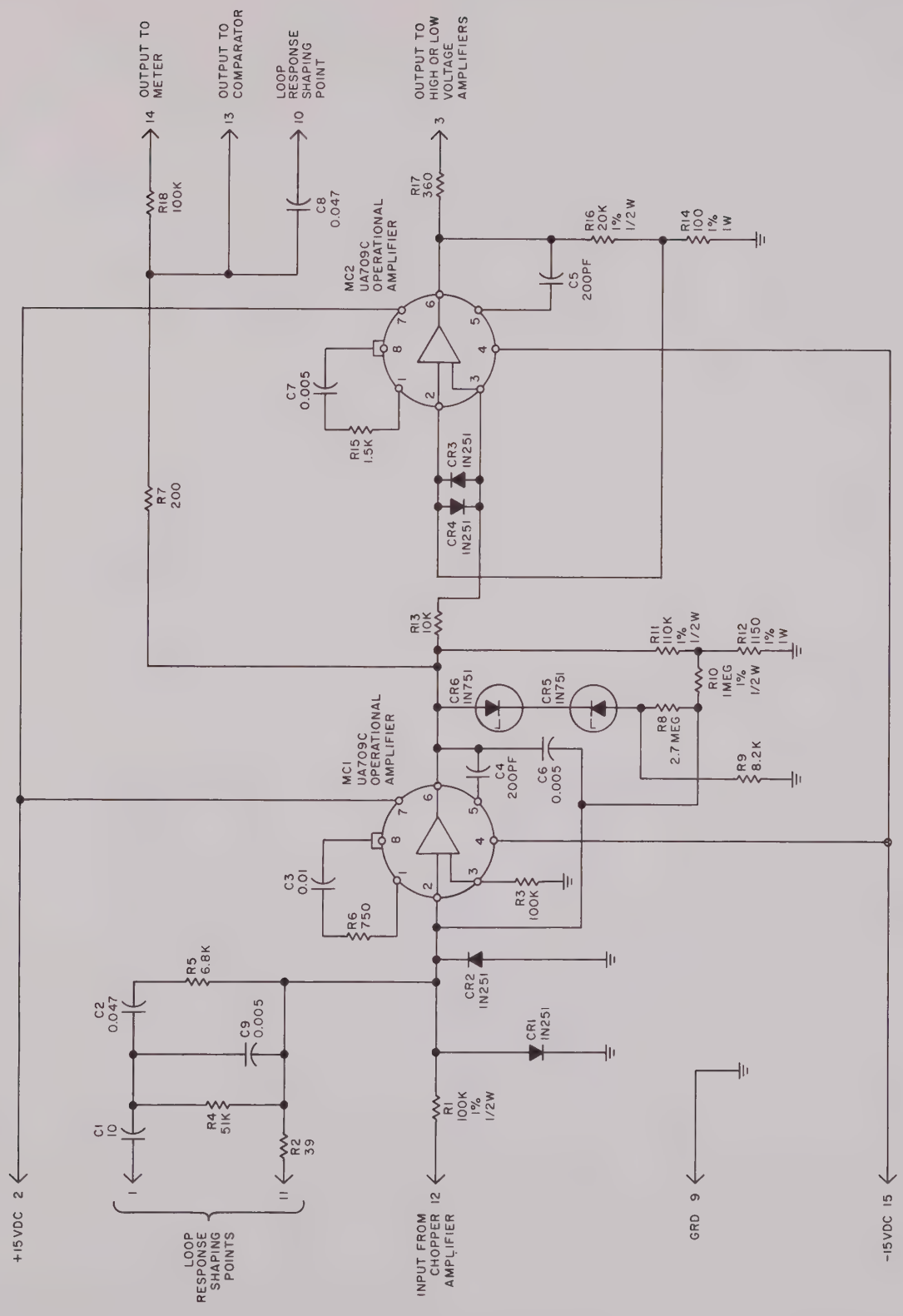


Figure 5-5. Dc Amplifier A3, Schematic Diagram

106-0560 00

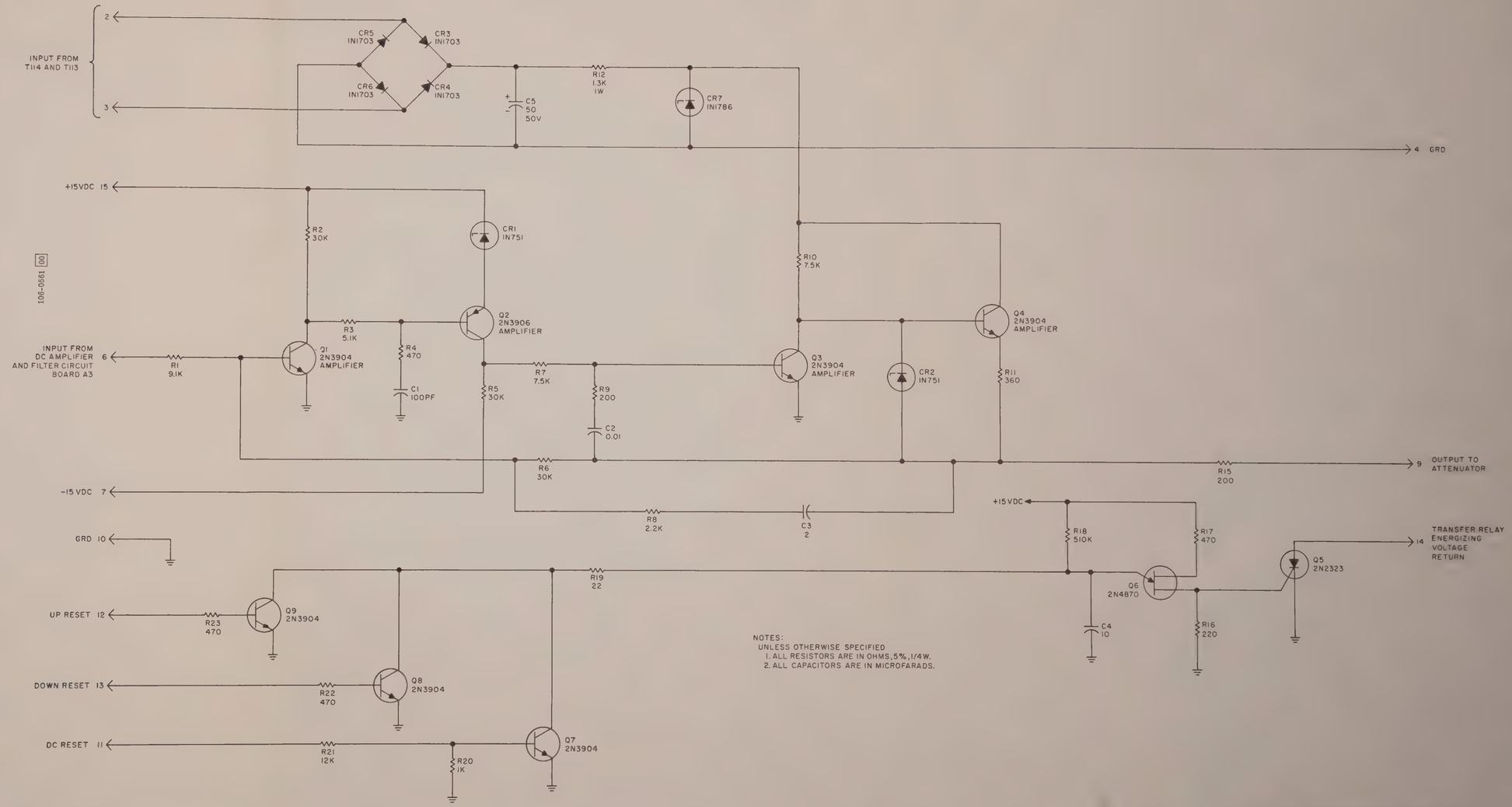


Figure 5-6. Low Voltage Amplifier A4, Schematic Diagram

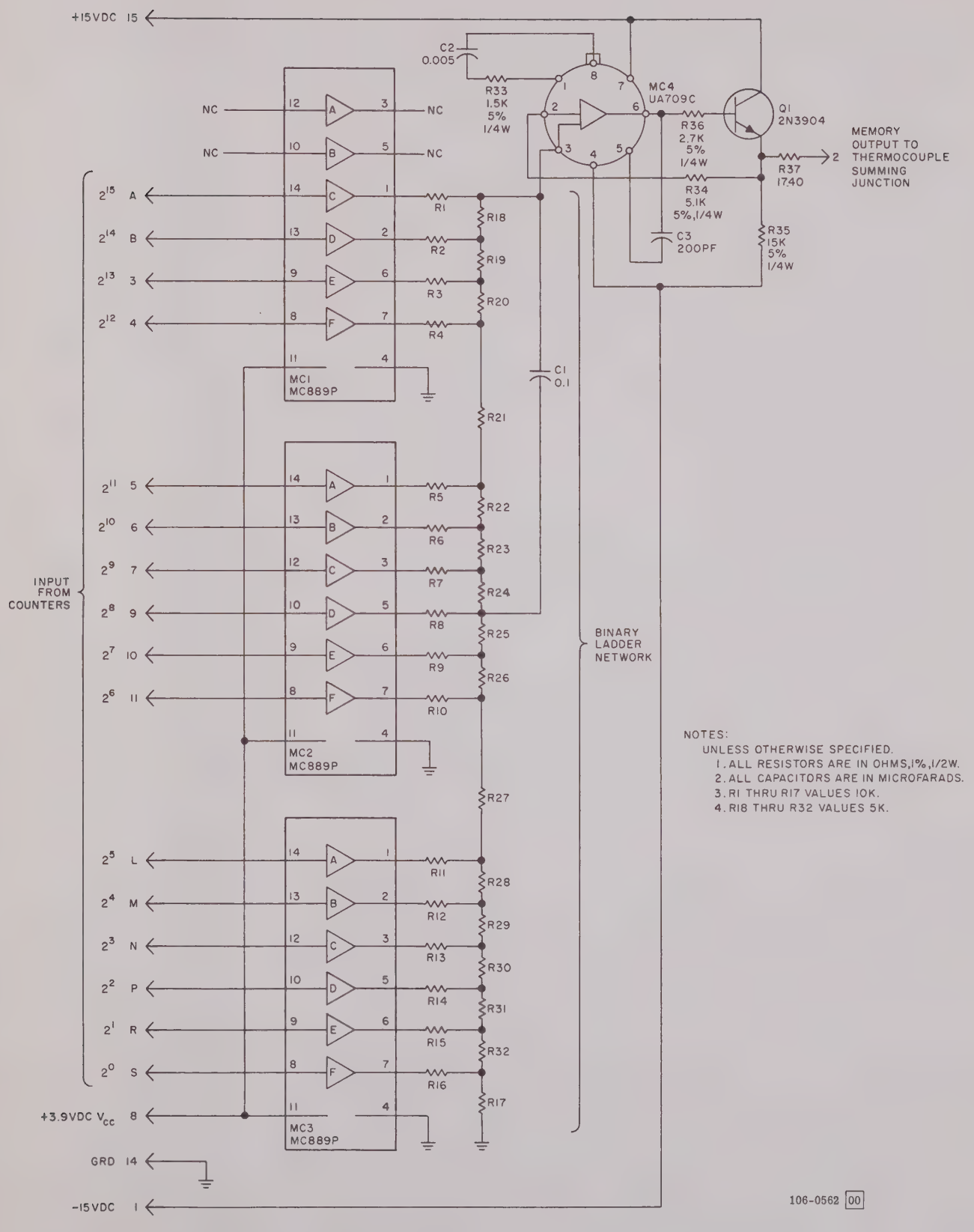
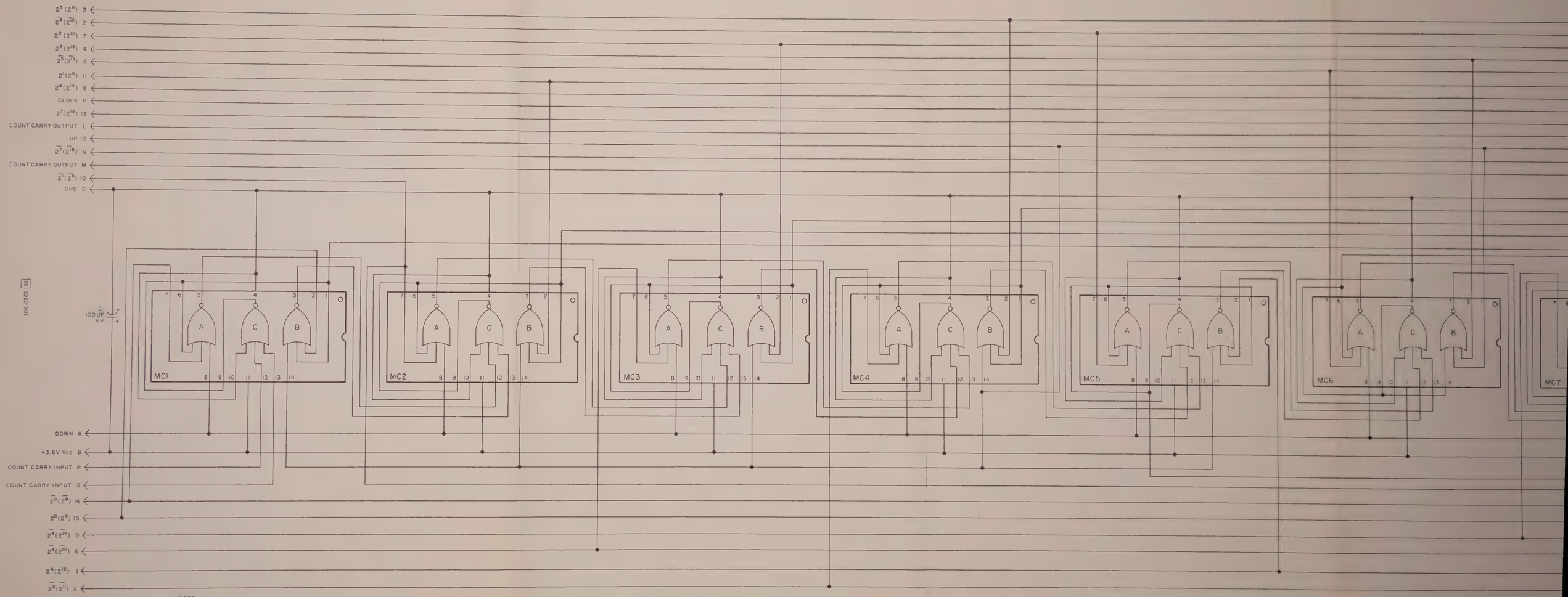


Figure 5-7. Ladder and Buffer Amplifier A5, Schematic Diagram



NOTE:
INFORMATION SHOWN IN PARENTHESIS APPLIES TO MODULE A7 ONLY.

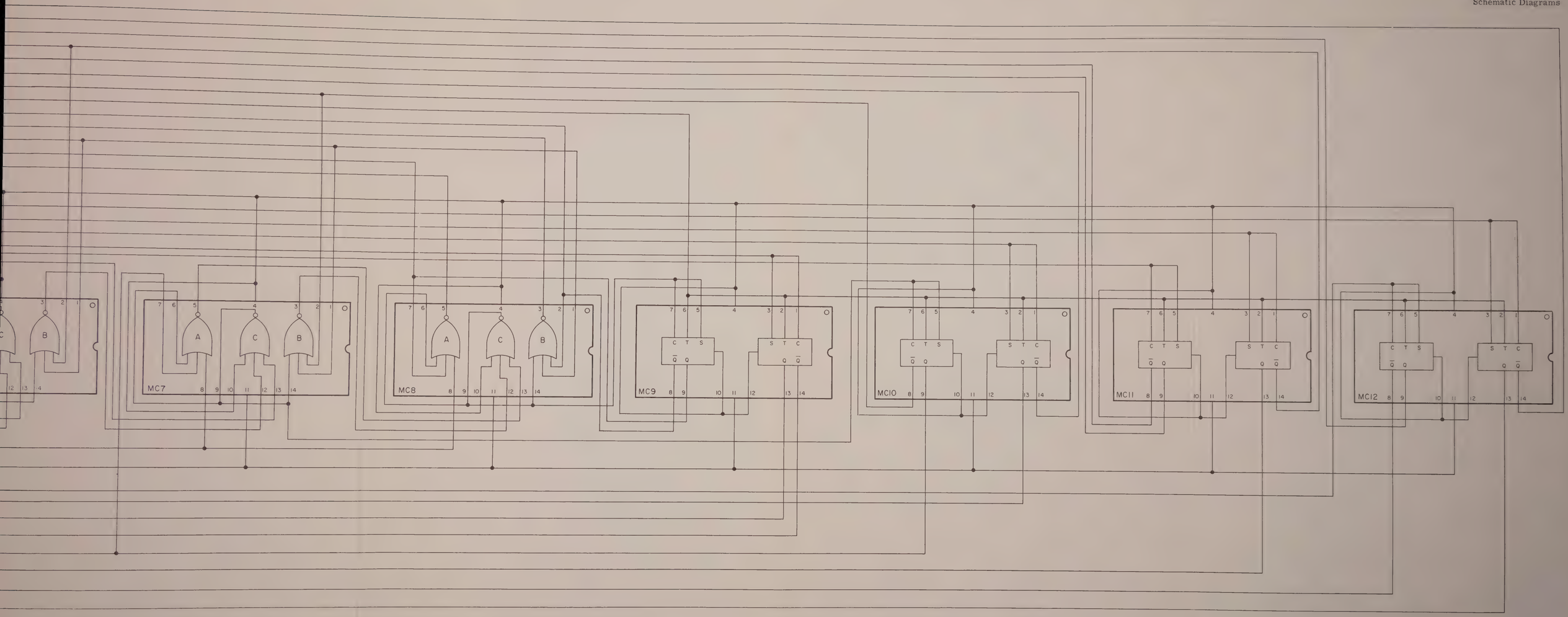


Figure 5-8. Counters A6 and A7, Schematic Diagram

Figure 5-9. Clock Oscillator A8, Schematic Diagram

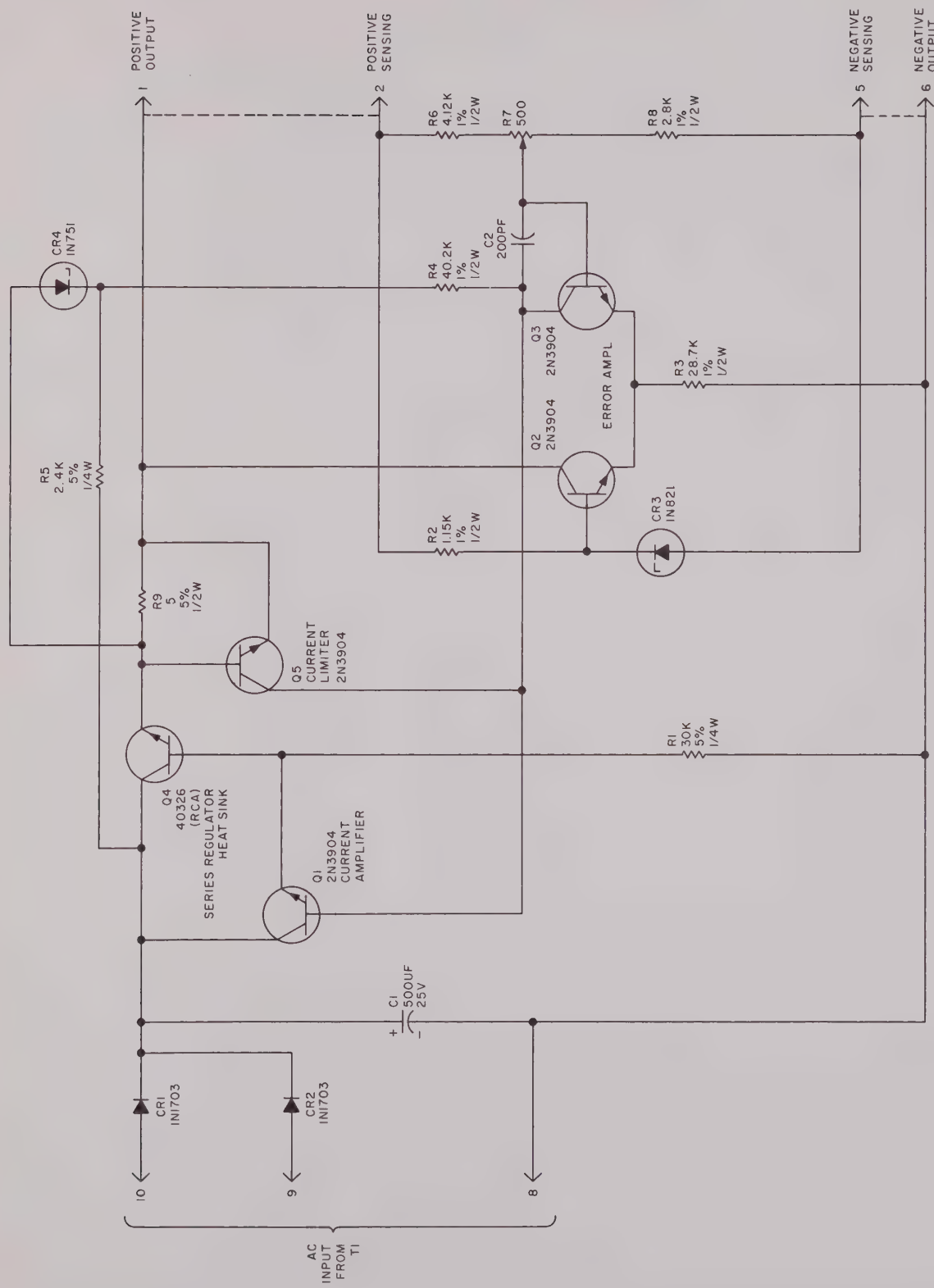


Figure 5-10. ±15 Volt Supplies A9 and A10, Schematic Diagram

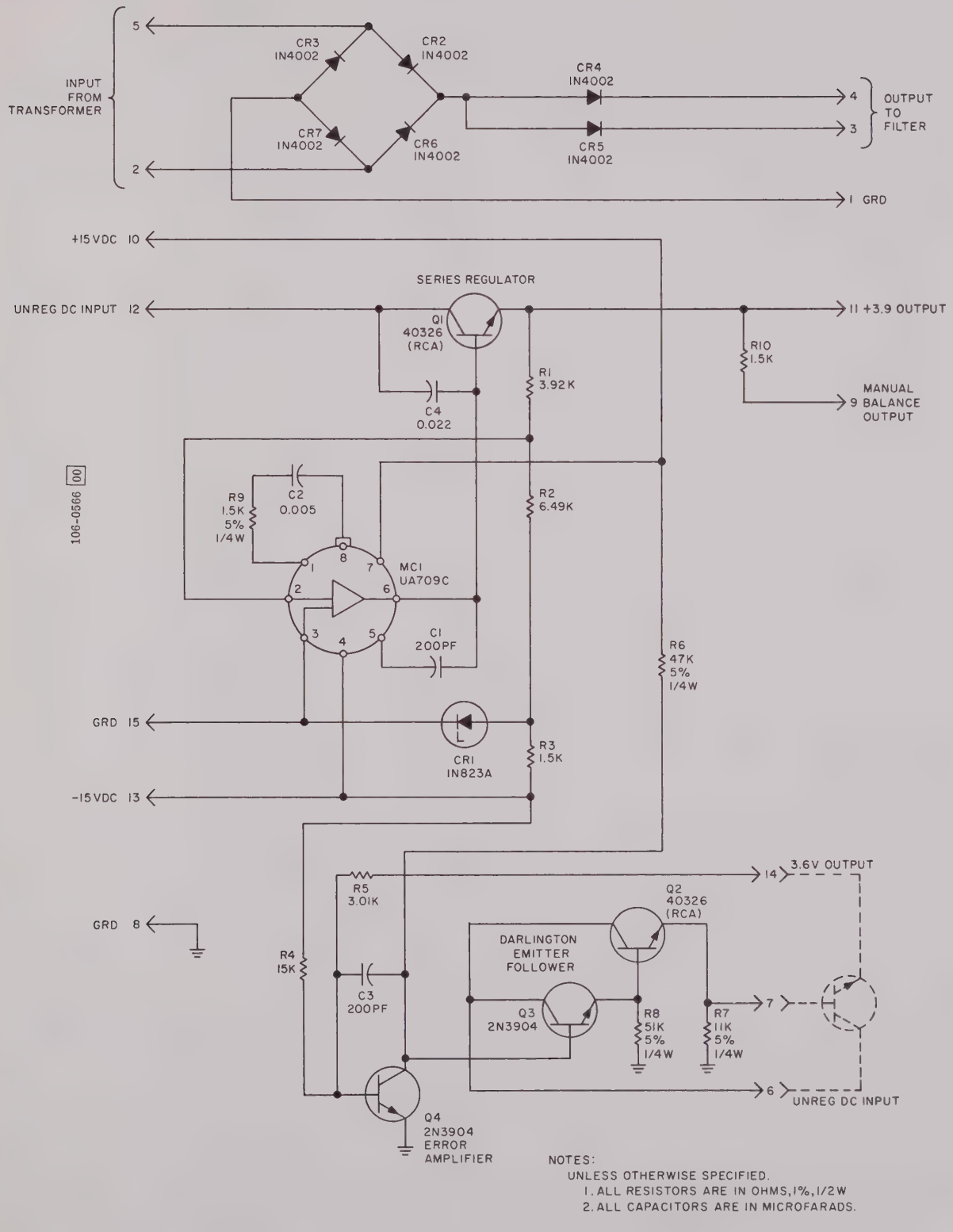
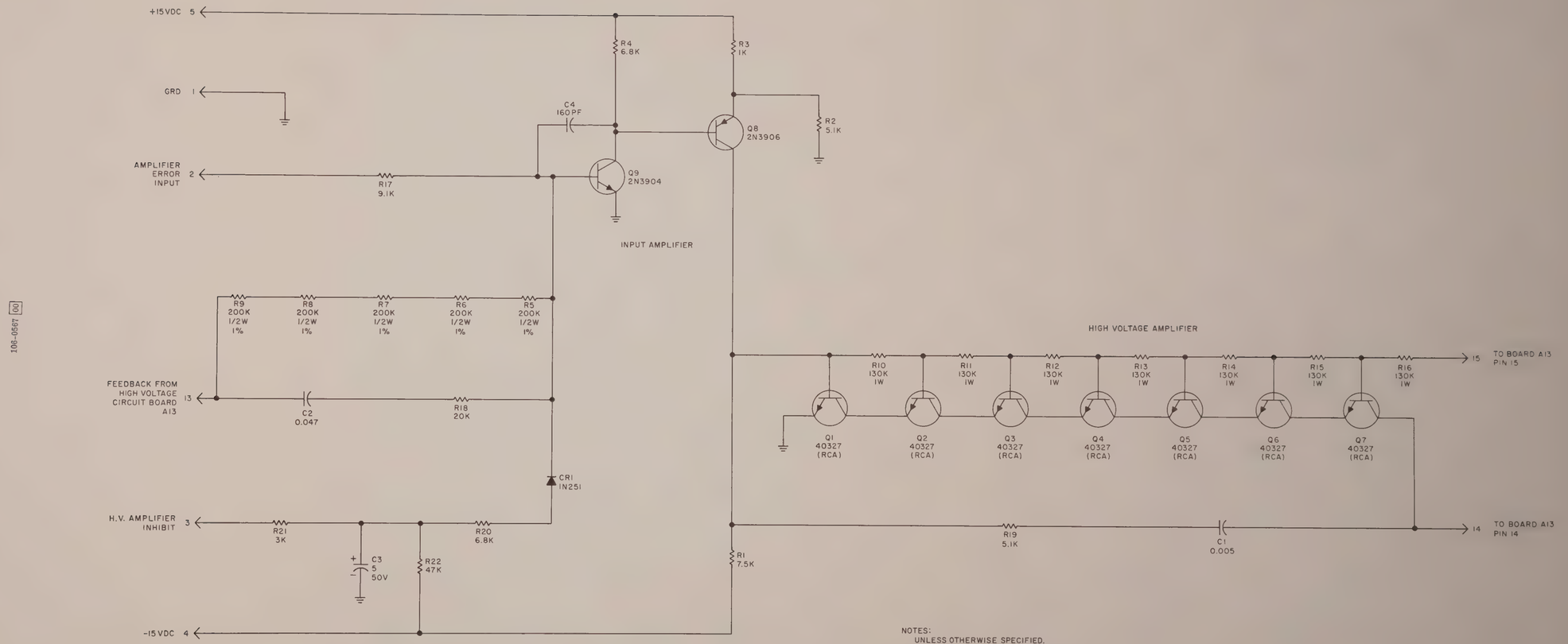
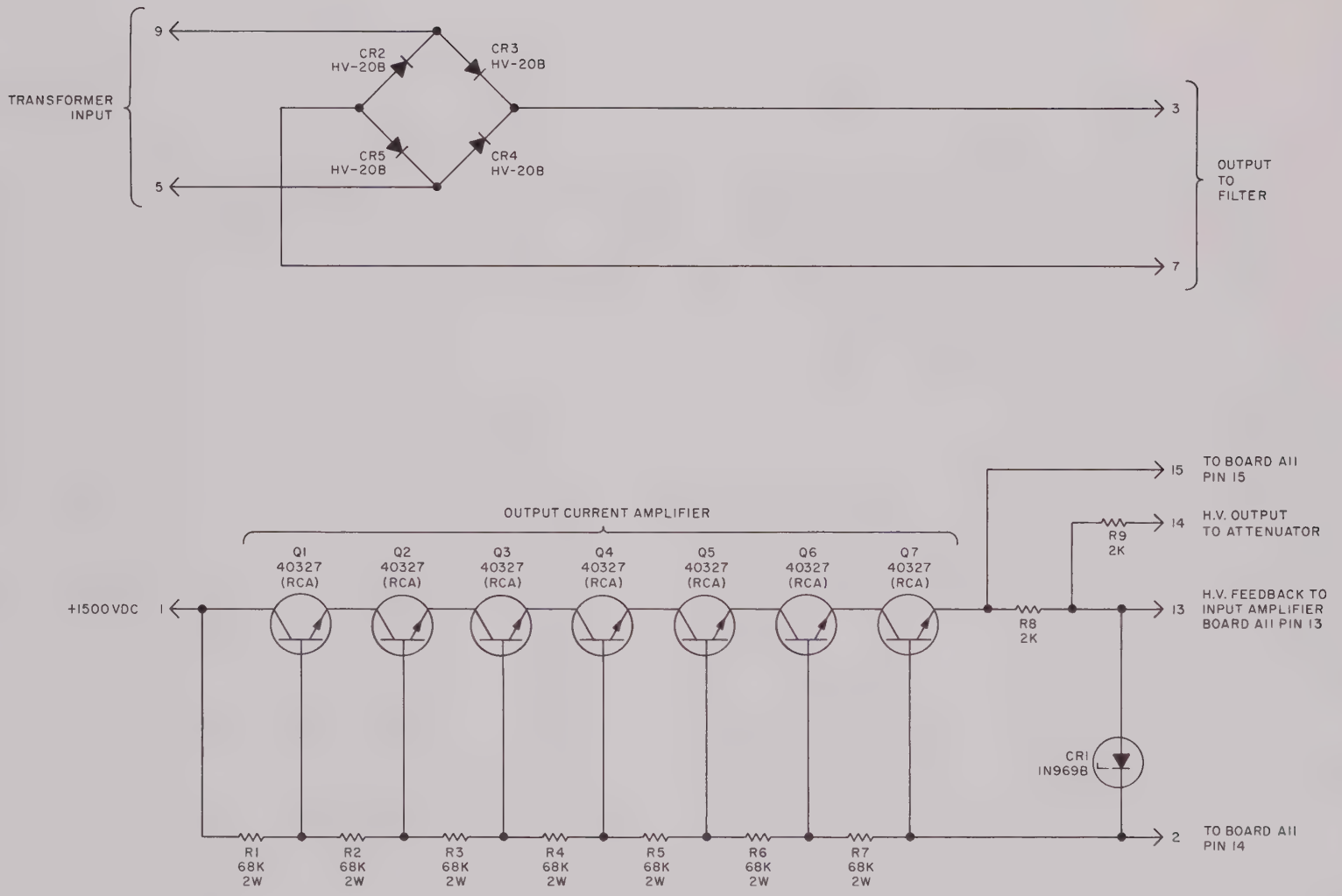


Figure 5-11. Low Voltage Supply A11, Schematic Diagram



NOTES:
UNLESS OTHERWISE SPECIFIED:
1. ALL RESISTORS ARE IN OHMS, 5%, 1/4W
2. ALL CAPACITOR ARE IN MICROFARADS

Figure 5-12. High Voltage Amplifier A12, Schematic Diagram



NOTE:
UNLESS OTHERWISE SPECIFIED, ALL RESISTORS ARE IN OHMS, 5%, 1/4W.

Figure 5-13. High Voltage Amplifier A13, Schematic Diagram

SECTION VI

PARTS LIST

6-1. INTRODUCTION

6-2. This parts list section includes all pertinent data necessary to locate, identify, and procure additional parts for the equipment. Parts are listed alpha-numerically by reference symbol and include all replaceable items such as electronic, electro-mechanical, and mechanical parts of the equipment. In some cases, values, ratings and manufacturer sources shown are nominal and variations may be found. Satisfactory replacement may be made with either the listed component or an exact replacement of the part(s) removed from the equipment.

6-3. ORDERING INFORMATION.

6-4. The following instructions will aid in ordering parts from the Parts List, table 6-2.

a. Address all inquiries or orders to:

CUSTOMER SERVICE
Department 500-1
The Singer Company
Metrics Division
915 Pembroke Street
Bridgeport, Connecticut 06608

b. Include the following information:

1) Model and Serial Number of instrument.

2) Singer Part Number.

3) Reference Symbol Number.

4) Description (as shown on list)

6-5. HOW TO USE THE PARTS LIST.

6-6. Paragraphs 6-7 through 6-11 describe the use and meaning of the five columns included in the parts list, table 6-2 (see figure 6-1).

6-7. REF SYMBOL COLUMN. The Ref Symbol Column (1, figure 6-1) contains a alpha-numerical listing of parts as they appear on equipment chassis, illustration, or schematic. The reference designation identifies the parts as to their component function in the instrument.

6-8. DESCRIPTION COLUMN. The Description Column (2, figure 6-1) contains the identification of component parts including all pertinent specifications and Singer part number. When the description column is used for a part which is identical to a part which has already been described: SAME AS (3) is used along with the reference symbol of the previously used part. In these instances, columns 3, 4, 5 are left blank. When the description column is used for a reference symbol for which no part exists; NOT USED (4) is placed in the column. In these instances, columns 3, 4, 5, are left blank.

6-9. MANUFACTURER'S PART NUMBER COLUMN. The Manufacturer's Part Number Column (5, figure 6-1) contains the part number as designated by the manufacturer of the part.

6-10. MFR'S CODE COLUMN. The Mfr's Code column (6, figure 6-1) references the manufacturer by an assigned code number as listed in Federal Supply Code Handbook H4-2. For manufacturers not listed in H4-2, a letter code will be assigned. Table 6-1 includes the manufacturer and his code designation.

6-11. MAINT QTY COLUMN. The Maint Qty column (7, figure 6-1) contains the number of additional components recommended to keep the equipment at an optimum performance level. The recommended number of components in the Maint Qty column is based on 2000 hours of equipment operation.

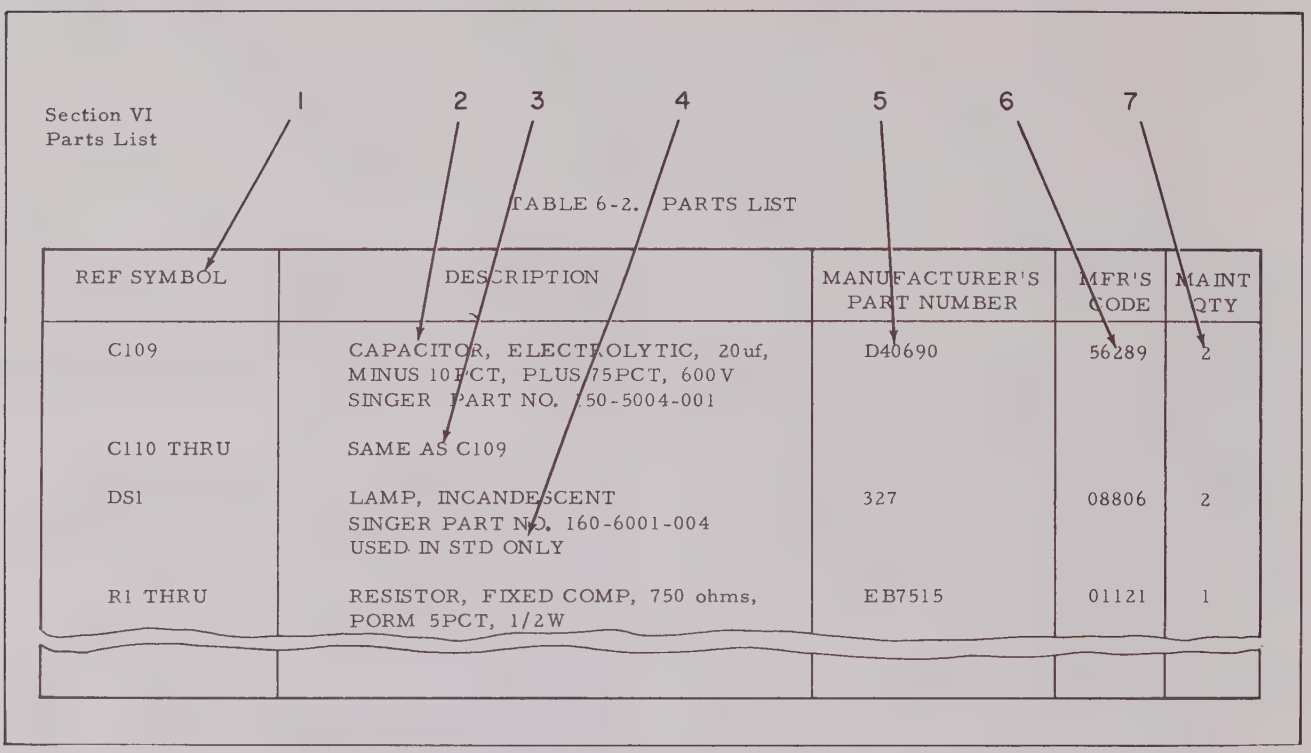


Figure 6-1. Parts List Sample

TABLE 6-1. MANUFACTURER'S CODE

Number	Name
INSTD	Industry Standard
00348	Microtan Co., Inc. Valley Stream, N.Y.
00656	Aerovox Corp. New Bedford, Mass.
01002	General Electric Co. Capacitor Department Hudson Falls, N.Y.
01121	Allen-Bradley Co. Milwaukee, Wis.
01295	Texas Instruments Inc. Semiconductor-Components Div. Dallas, Texas
02660	Amphenol-Borg Electronics Corp. Maywood, Ill.
03508	General Electric Co. Semi-Conductor Products Dept. Electronics Park Syracuse, N.Y.
04713	Motorola Inc. Semiconductor Products Division Phoenix, Arizona
07263	Fairchild Camera and Instrument Corp. Semiconductor Division Mountain View, Calif.
12126	Kidco Inc. Medford, N.J.
12617	Hamlin Inc. Lake Mills, Wis.
13327	Solitron Devices Inc. Tappan, N.Y.
14195	Electronic Controls Wilton, Conn.
16665	The Singer Company Metrics Division Bridgeport, Conn.
19396	Illinois Tool Works Inc. Paktron Division Alexandria, Va.
24655	General Radio Co. West Concord, Mass.
31356	J-B-T Instruments Inc. New Haven, Conn.

TABLE 6-1. MANUFACTURER'S CODE (Cont'd)

Number	Name
53021	Sangamo Electric Co. Springfield, Ill.
56289	Sprague Electric Co. North Adams, Mass.
58474	The Superior Electric Co. Bristol, Conn.
71482	C.P. Clare and Co. Chicago, Ill.
71590	Centralab Division of Globe-Union Inc. Milwaukee, Wis.
72136	Electro-Motive Mfg. Co., Inc. Willimantic, Conn.
72928	Gudeman Co. Chicago, Ill.
72982	Erie Technological Products Inc. Erie, Pa.
73138	Beckman Instruments Inc. Helipot Division Fullerton, Calif.
75042	International Resistance Co. Philadelphia, Pa.
75915	Littelfuse Inc. Des Plaines, Ill.
80223	United Transformer Co. New York, N.Y.
81349	Military Specifications
81483	International Rectifier Corp. El Segundo, Calif.
81541	Airpax Electronics Cambridge, Md.
82389	Switchcraft Inc. Chicago, Ill.
86684	Radio Corp. of America Electronic Components and Devices Harrison, N.J.
88245	Litton Industries USECO Division Van Nuys, Calif.
88557	Central Lab Mfg. Co. Brooklyn, N.Y.
91418	Radio Materials Co. Chicago, Ill.
91929	Minneapolis-Honeywell Regulator Micro-Switch Division Freeport, Ill.
92966	Hudson Lamp Co. Kearny, N.J.
93332	Sylvania Electric Products Inc. Semiconductor Products Division Woburn, Mass.
93790	Cornell-Dubilier Electronic Division Federal Pacific Electric Corp. New Bedford, Mass.
95263	Leecraft Mfg. Co., Inc. Long Island City, N.Y.
95354	Methode Mfg. Co. Chicago, Ill.
96256	Thordarson-Meissner Inc. Mt. Carmel, Ill.
99515	Marshall Industries Electron Products Division San Marino, Calif.

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
CR1	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556118-176	1N4002	INSTD	1
CR2 AND CR3	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556118-046	1N251	93332	1
C1	CAPACITOR,FIXED,PAPER, 1UF,2000V SINGER PART NO. 556147-189	23F1245	01002	1
C2	CAPACITOR,FIXED,ELECTROLYTIC, 2000 UF,PLUS 100 MINUS 10 PCT,15V SINGER PART NO. 556062-003	TVL-1168	56289	1
C3	CAPACITOR,FIXED,ELECTROLYTIC, 1000 UF,PLUS 150 MINUS 10 PCT,15V SINGER PART NO. 556074-146	BR1000-15	93790	1
C4	CAPACITOR,FIXED,CERAMIC DISC, 0.01 UF,2000V SINGER PART NO. 556060-062	2KV/0.0.UF HI-K	91418	1
C5	CAPACITOR,FIXED,CERAMIC DISC, 0.022 UF,PLUS 80 MINUS 20 PCT,25V SINGER PART NO. 556060-105	C069B25CG223Z	56289	1
DS1 AND DS2	LIGHT,PILOT SINGER PART NO. 556147-106	41EN-G5-2314	95263	4
DS3	LAMP,INCANDESCENT SINGER PART NO. 160-6001-004	327	92966	3
G1	CHOPPER,SPDT,NON-SHORTING SINGER PART NO. 556147-111	2580-1	81541	1
J1 THRU J13	CONNECTOR,JACK SINGER PART NO. 168-3002-105	81-6030-1106-00	95354	1
J14	CONNECTOR,JACK SINGER PART NO. 556147-185	MS3102A16S-1S	02660	1
K1	RELAY SINGER PART NO. 556147-192	801-8C24-GM	14195	1
L1	TRANSFORMER SINGER PART NO. 556147-153	20C51	96256	1
M1	METER	134-0027-001	16665	1
P1	CONNECTOR,PLUG SINGER PART NO. 556016-074	MS3106A10SL-3S	02660	1
P2	CONNECTOR,PLUG SINGER PART NO. 556147-107	57-30140	02660	1
P3	CONNECTOR,PLUG SINGER PART NO. 556147-108	57-30240	02660	1
P4	CONNECTOR,PLUG SINGER PART NO. 556147-186	MS3106A16S-1P	02660	1
Q1	TRANSISTOR, SINGER PART NO. 556147-121	2N4921	04713	1
R1	RESISTOR,VARIABLE, 100 OHMS,PORM .25 PCT,5W SINGER PART NO. 556147-130	A-R100-L.25	73138	1
R2	RESISTOR,VARIABLE, 10K OHMS,PORM .25 PCT,5W SINGER PART NO. 556147-131	A-R10K-L.25	73138	1
R3	RESISTOR,FIXED,WIRE-WOUND, 4.4 OHMS,PORM 1 P SINGER PART NO. 556147-252	WW4J/20HMSPORM1PCT	75042	1
R4	RESISTOR,FIXED,FILM 150K OHMS,PORM 1 PCT, 1/2W SINGER PART NO. 151-2012-A1503F	M1/2E150KOHMPORM1PCT	12126	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
R5 AND R6	RESISTOR,FIXED,COMP., 150 OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-151J	EB1515	01121	1
R7	RESISTOR,FIXED,COMP., 1000 OHMS PORM 5PCT 1/4W SINGER PART NO. 151-1002-102J	CB1025	01121	1
S1	SWITCH	133-0099-001	16665	1
S2	SWITCH,PUSH BUTTON,SPDT SINGER PART NO. 556147-100	36SCA0P11R00	88245	1
S3	SWITCH,PUSH-BUTTON,MOMENTARY ACTION SINGER PART NO. 161-0007-001	923D TYPE	82389	1
S4	SWITCH,PUSH-BUTTON,SPDT SINGER PART NO. 556147-098	46SCA0P11X00	88245	1
S5	SAME AS S3			
T1	TRANSFORMER,POWER	132-0313-001	16665	1
T2	TRANSFORMER,HIGH VOLTAGE	132-0314-001	16665	1
T3	TRANSFORMER,CHOPPER INPUT SINGER PART NO. 556147-151	M8052	00348	1
A1	TRANSFER SUB ASSY MODEL ATS-TA	103-1723-001	16665	1
A1BR1	RECTIFIER,SINGLE-PHASE FULL-WAVE BRIDGE SINGER PART NO. 556147-156	MDA952-2	04713	1
A1CR1 THRU CR7	SAME AS CR1			
A1C1	CAPACITOR,FIXED,ELECTROLYTIC, 2000 PF,50V SINGER PART NO. 556075-001	DCM2000PF50V	53021	1
A1C2	CAPACITOR,FIXED,DIPPED MICA, 5 PF,PORM 5 PCT 500V SINGER PART NO. 15C-2002-5R0CD	DM15C5R0D0500WV4CR	72136	1
A1C3	CAPACITOR,FIXED,CERAMIC PORM 20 PCT 3KV SINGER PART NO. 556060-041	DD30-502	88557	1
A1DS1	SAME AS DS3			
A1E1	POST,BINDING RED SINGER PART NO. 556016-338	DF3CRC	58474	1
A1E2	POST,BINDING BLACK SINGER PART NO. 556016-337	DF30BC	58474	1
A1F1	FUSE,CARTRIDGE, 1/2 AMP.250V SINGER PART NO. 556006-023	312.500	75915	5
A1J1	CONNECTOR,JACK SINGER PART NO. 556010-052	MS3102A10SL-3P	02660	1
A1J2	CONNECTOR,JACK SINGER PART NO. 556147-109	57-40140	02660	1
A1J3	CONNECTOR,JACK SINGER PART NO. 556147-110	57-40240	02660	1
A1J4	CONNECTOR,JACK SINGER PART NO. 168-3002-005	71-6015-1106-00	95354	1
A1J5	CONNECTOR,JACK	149-0169-001	16665	1
A1J6	CONNECTOR,JACK SINGER PART NO. 556147-127	0874-9447	24655	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A1K9 THRU K20	NON-REPLACEABLE PART OF HIGH VOLTAGE ATTENUATOR ASSY			
A1L1	RELAY SINGER PART NO. 556147-137	A-469287	71482	1
A1L2 THRU L8	NON-REPLACEABLE PART OF LOW VOLTAGE ATTENUATOR ASSY			
A1L9	COIL,RELAY ACTUATOR	103-1715-008	16665	1
A1L10	COIL,RELAY ACTUATOR	103-1715-001	16665	1
A1P1	CORD, LINE, AC	556161-212	16665	1
A1R1 THRU R7	NON-REPLACEABLE PART OF LOW VOLTAGE ATTENUATOR ASSY			
A1R8 AND R9	RESISTOR,WIRE-WOUND,30K OHMS,PORM 1 PCT,5W SINGER PART NO. 556147-136	AS-5/30K/PORM1PCT	75042	1
A1R10	RESISTOR,FIXED,DEPOSITED CARBON, 780 OHMS, PORM 1 PCT,1/2W SINGER PART NO. 151-1007-B7800F	C1/2E780OHMPORM1PCT	12126	1
A1R11	RESISTOR,FIXED,DEPOSITED CARBON, 1.2K OHMS, PORM 1 PCT,1/2W SINGER PART NO. 151-1007-B1201F	C1/2E1200OHMPORM1PCT	12126	1
A1R12	RESISTOR,FIXED,DEPOSITED CARBON, 1.8K OHMS, PORM 1 PCT,1/2W SINGER PART NO. 151-1007-B1801F	C1/2E1800OHMPORM1PCT	12126	1
A1R13	RESISTOR,FIXED,DEPOSITED CARBON, 1000 OHMS PORM 1 PCT,1/2W SINGER PART NO. 151-1007-B1001F	C1/2E1000OHMPORM1PCT	12126	1
A1R14	RESISTOR,FIXED,DEPOSITED CARBON,. 8060 OHMS, PORM 1 PCT,1/2W SINGER PART NO. 151-1007-B8061F	C1/2E8C60OHMPORM1PCT	12126	1
A1R15	RESISTOR,FIXED,DEPOSITED CARBON, 80.6K OHMS PORM 1 PCT,1/2W SINGER PART NO. 151-1007-B8062F	C1/2E80.6KPORM1PCT	12126	1
A1R16	RESISTOR,FIXED,DEPOSITED CARBON, 806K OHMS PORM 1 PCT,1/2W SINGER PART NO. 151-1007-B8063F	C1/2E806KOHMPORM1PCT	12126	1
A1R17	RESISTOR,FIXED,DEPOSITED CARBON, 8.06 MEGOHM PORM 1 PCT,1/2W SINGER PART NO. 151-1007-B8C64F	C1/2E8.06MEGPORM1PCT	12126	1
A1R18	SAME AS A1R8			
A1R19 THRU R39	NON-REPLACEABLE PART OF HIGH VOLTAGE ATTENUATOR ASSY			
A1R40	RESISTOR,FIXED,COMP., 10 OHMS,P3RM 5 PCT,2W SINGER PART NO. 151-1005-100J	HB1CC5	01121	1
A1R41	SAME AS A1R8			
A1R42	SAME AS R5			
A1S1	SWITCH,PUSH-BUTTON,SPDT SINGER PART NO. 556147-099	46SCA0P11G00	88245	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A1S2	SWITCH,SLIDE,DPDT SINGER PART NO. 556146-590	S-330	82389	1
A1S3	SWITCH,ROTARY,6 DECKS,14 POSITION SINGER PART NO. 556147-135	MAS-14-6-Q72	31356	1
A1S4	SWITCH,PUSH,SPDT,3AMP,125V SINGER PART NO. 556019-356	1S723-T	91929	1
A1S5 THRU S11	NON-REPLACEABLE PART OF LOW VOLTAGE ATTENUATOR ASSY			
A1S12 AND S13	SWITCH,REED SINGER PART NO. 556147-138	TYPE MTRF	12617	1
A1TC1	THERMO-ELEMENT	556147-119	16665	2
A1T1	TRANSFORMER,CONTROL SINGER PART NO. 556147-154	23V159	96256	1
A1XF1	FUSEHOLDER SINGER PART NO. 556006-015	342C04	75915	1
A1A1	OVERLOAD SENSING PREAMPLIFIER ASSY	103-1705-001	16665	1
A1A1CR1 AND CR2	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556146-089	1N4009	INSTD	1
A1A1CR3 THRU CR6	SAME AS CR2			
A1A1CR7	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556118-111	1N1786	81483	1
A1A1C1	CAPACITOR,FIXED,PLASTIC, 0.1 UF,PERM 20 PCT, 200V SINGER PART NO. 556120-098	338C104M	72928	1
A1A1C2 AND C3	CAPACITOR,FIXED,CERAMIC, 0.47 UF,PERM 20PCT 25V SINGER PART NO. 556120-160	5C11	56289	1
A1A1Q1 AND Q2	TRANSISTOR MATCHED SET	132-0316-001	16665	1
A1A1Q3 THRU Q6	TRANSISTOR SINGER PART NO. 556146-989	2N3904	81349	3
A1A1Q7	TRANSISTOR SINGER PART NO. 556146-988	2N3906	81349	1
A1A1Q8	TRANSISTOR SINGER PART NO. 556147-125	2N2323	03508	1
A1A1Q9	TRANSISTOR SINGER PART NO. 556118-167	2N1711	04713	1
A1A1Q10 AND Q11	SAME AS A1A1Q3			
A1A1R1 AND R2	RESISTOR,FIXED,COMP., 6.8KOHMS,PERM 5 PCT, 1/4W SINGER PART NO. 151-1002-682J	CB6825	01121	1
A1A1R3 AND R4	RESISTOR,FIXED,COMP., 3.9K OHMS,PERM 5 PCT, 1/4W SINGER PART NO. 151-1002-392J	CB3925	01121	1
A1A1R5	RESISTOR,VARIABLE, 1000 OHMS, .75W SINGER PART NO. 556147-133	77P-R1K	73138	1
A1A1R6	RESISTOR,FIXED,COMP., 43K OHMS,PERM 5 PCT, 1/4W SINGER PART NO. 151-1002-433J	CB4335	01121	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A1A1R7 AND R8	RESISTOR.FIXED.COMP., 5.1K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-512J	CB5125	01121	1
A1A1R9	RESISTOR.FIXED.COMP., 750 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-751J	CB7515	01121	1
A1A1R10	SAME AS A1A1R6			
A1A1R11 THRU R15	RESISTOR.FIXED.COMP., 20K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-203J	CB1035	01121	1
A1A1R16	RESISTOR,VARIABLE, 5K OHMS, .75W SINGER PART NO. 556147-134	77P-R5K	73138	1
A1A1R17	SAME AS A1A1R7			
A1A1R18	SAME AS R7			
A1A1R19 AND R20	RESISTOR.FIXED.COMP., 15K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-153J	CB1535	01121	1
A1A1R21 AND R22	SAME AS A1A1R18			
A1A1R23	RESISTOR,FIXED,COMP., 1.5K OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-152J	EB1525	01121	1
A1A1R24	RESISTOR.FIXED.COMP., 100K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-104J	CB1045	01121	1
A1A1R25	SAME AS A1A1R19			
A2	CHOPPER AMPLIFIER	103-1710-001	16665	1
A2C1 AND C2	CAPACITOR,CERAMIC DISC 1000PF 500V SINGER PART NO. 150-1002-102PHC	801-00X5P0102GMV	72982	1
A2C3	CAPACITOR,FIXED,ELECTROLYTIC, 100 UF,PLUS 75 MINUS 10 PCT,3V SINGER PART NO. 150-5001-101AS	30D107G003CB4	56289	1
A2C4 AND C5	CAPACITOR,FIXED,ELECTROLYTIC, 35 UF,PLUS 75 MINUS 10 PCT,15V SINGER PART NO. 150-5001-35CDS	30D356G015CB4	56289	1
A2C6 AND C7	CAPACITOR,FIXED,MYLAR, 1UF, 100V SINGER PART NO. 556147-145	2D1-105	99515	1
A2C8 AND C9	CAPACITOR,FIXED,ELECTROLYTIC, 50 UF,PLUS 75 MINUS 10 PCT,15V SINGER PART NO. 556074-026	30D506G015CP4	56289	1
A2Q1 THRU Q3	TRANSISTOR SINGER PART NO. 556147-155	2N3391A	03508	1
A2Q4 AND Q5	TRANSISTOR SINGER PART NO. 556017-044	2N1306	01295	1
A2R1	RESISTOR,FIXED,FILM, 243K OHMS,PORM 1 PCT, 1/2W SINGER PART NO. 151-2012-A2433F	M1/2E243KOHMPORM1PCT	12126	1
A2R2	RESISTOR.FIXED.COMP., 39K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-393J	CB3935	01121	1
A2R3	RESISTOR,FIXED, FILM, 243 OHMS,PORM 1 PCT, 1/2W SINGER PART NO. 151-2012-A2430F	M1/2E243OHMPORM1PCT	12126	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A2R4	RESISTOR.FIXED.COMP., 270KOHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-274J	CB2745	01121	1
A2R5	RESISTOR.FIXED.COMP., 56K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-563J	CB5635	01121	1
A2R6	RESISTOR.FIXED.COMP., 75K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-753J	CB7535	01121	1
A2R7	RESISTOR.FIXED.COMP., 9.1K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-912J	CB9125	01121	1
A2R8	SAME AS A1A1R11			
A2R9	RESISTOR.FIXED.COMP., 30K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-303J	CB3035	01121	3
A2R10	SAME AS A1A1R24			
A2R11 AND R12	RESISTOR.FIXED.COMP., 8.2K OHMS.PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-822J	CB8225	01121	1
A2R13 AND R14	RESISTOR.FIXED.COMP., 1.2K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-122J	CB1225	01121	1
A2R15 AND R16	RESISTOR.FIXED.COMP., 510 OHMS, PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-511J	CB5115	01121	1
A2T1	TRANSFORMER SINGER PART NO. 556147-152	0-26	80223	1
A3	DC AMPLIFIER / FILTER	103-1704-001	16665	1
A3CR1 THRU CR4	SAME AS CR2			
A3CR5 AND CR6	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556118-171	1N751	INSTD	1
A3C1	CAPACITOR,FIXED,MYLAR, 10 UF,100V SINGER PART NO. 556147-146	2D1-106	99515	1
A3C2	CAPACITOR,FIXED, POLYESTER,.047 UF PORM 10PC 50V SINGER PART 556120-191	MW-600/0.047VF	19396	1
A3C3	CAPACITOR,FIXED,CERAMIC DISC, 0.01 UF,GMV, 500V SINGER PART NO. 150-1002-103PHF	811-000XP0103GMV	72982	1
A3C4 AND C5	CAPACITOR,FIXED,MICA, 200 PF,PORM 5 PCT,500V SINGER PART NO. 556079-008	CM15E201J	72136	1
A3C6	CAPACITOR,FIXED, CERAMIC DISC,5000PF,GMV, 1000V SINGER PART NO 556060-145	1KV/5000PFGMV	91418	1
A3C7	CAPACITOR,FIXED,CERAMIC DISC, 0.005 UF,GMV, 500V SINGER PART NO. 150-1002-502PHD	851-000Z5V0502GMV	72982	1
A3C8	SAME AS A3C2			
A3C9	SAME AS A3C6			
A3MC1 AND MC2	INTEGRATED CIRCUIT, AMPLIFIER SINGER PART NO. 556146-992	UA709C	07263	1
A3R1	RESISTOR,FIXED,FILM,100K OHMS,PORM 1PCT, 1/2W SINGER PART NO. 151-2012-A1003F	M1/2E100KOHMPORM1PCT	12126	1
A3R2	RESISTOR.FIXED.COMP., 39 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-390J	CB3905	01121	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A3R3	RESISTOR,FIXED,COMP.,100K OHMS PORM 5PCT, 1/4W SINGER PART NO 151-1002-104J	CB1045	01121	1
A3R4	RESISTOR,FIXED,COMP.,51K OHMS,PORM 5PCT, 1/4W SINGER PART NO 151-1002-513J	CB5135	01121	1
A3R5	SAME AS A1A1R1			
A3R6	SAME AS A1A1R9			
A3R7	RESISTOR.FIXED.COMP., 200 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-201J	CB2015	01121	1
A3R8	RESISTOR,FIXED,COMP.,2.7MEGOHMS,PORM 5PCT, 1/4W SINGER PART NO 151-1002-275J	CB2755	01121	1
A3R9	SAME AS A2R11			
A3R10	RESISTOR,FIXED,FILM,1MEGOHM,PORM 1PCT, 1/2W SINGER PART NO 151-2012-A1004F	M1/2E1MOHMPORM1PCT	12126	1
A3R11	RESISTOR,FIXED,FILM, 110K OHMS,PORM 1 PCT, 1/2W SINGER PART NO. 151-2012-A1103F	M1/2E110KOHMP/RM1PCT	12126	1
A3R12	RESISTOR,FIXED,FILM, 1150 OHMS,PORM 1 PCT, 1W SINGER PART NO. 151-2012-A1151F	M1/2E1150OHMPORM1PCT	12126	1
A3R13	SAME AS A1A1R11			
A3R14	RESISTOR,FIXED,FILM, 1000HMS,PORM 1 PCT, 1W SINGER PART NO. 151-2012-A1000F	M1/2E1000HMSPORM1PCT	12126	1
A3R15	RESISTOR.FIXED.COMP., 1.5K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-152J	CB1525	01121	1
A3R16	RESISTOR,FIXED,FILM, 20K OHMS,PORM 1 PCT, 1/2W SINGER PART NO. 151-2012-A2002F	M1/2E20KOHMPORM1PCT	12126	1
A3R17	RESISTOR.FIXED.COMP., 360 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-361J	CB3615	01121	1
A3R18	SAME AS A1A1R24			
A4	LOW VOLTAGE AMPLIFIER	103-1706-001	16666	1
A4CR1 AND CR2	SAME AS A3CR5			
A4CR3 THRU CR6	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 557010-006	1N1703	81483	1
A4CR7	SAME AS A1A1CR7			
A4C1	CAPACITOR,FIXED,DIPPED MICA, 100 PF,PORM 5 PCT,500V SINGER PART NO. 150-2002-101EJ0	DM15E101J0500WV4CR	72136	1
A4C2	CAPACITOR,FIXED,CERAMIC DISC, 0.01 UF,PLUS 60 MINUS 40 PCT,1K/V SINGER PART NO. 556060-146	DA140-172B	71590	1
A4C3	CAPACITOR,FIXED,METALLIZED PAPER, 2 UF,PORM 20 PCT,200V SINGER PART NO. 556120-142	P82S2ZN14	00656	1
A4C4	CAPACITOR,FIXED,ELECTROLYTIC, 10 UF,PLUS 75 MINUS 10 PCT,25V SINGER PART NO. 150-5001-100ES	30D106G025BB4	56289	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A4C5	CAPACITOR,FIXED,ELECTROLYTIC, 50 UF,PORM MK MINUS 10 PCT,50V SINGER PART NO. 150-5001-500FS	30D506G050DD4	56289	1
A4Q1	SAME AS A1A1C3			
A4C2	SAME AS A1A1C7			
A4C3 AND C4	SAME AS A1A1C3			
A4C5	SAME AS A1A1C8			
A4C6	TRANSISTOR SINGER PART NO. 556147-197	2N487C	04713	
A4C7 THRU C9	SAME AS A1A1C3			
A4R1	SAME AS A2R7			
A4R2	SAME AS A2R9			
A4R3	SAME AS A1A1R7			
A4R4	RESISTOR.FIXED.COMP., 470 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-471J	CB4715	01121	2
A4R5 AND R6	SAME AS A2R9			
A4R7	RESISTOR.FIXED.COMP., 7.5K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-752J	CB7525	01121	1
A4R8	RESISTOR.FIXED.COMP., 2.2K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-222J	CB2225	01121	1
A4R9	SAME AS A3R7			
A4R10	SAME AS A4R7			
A4R11	SAME AS A3R17			
A4R12	RESISTOR,FIXED,COMP., 1.3K OHMS,PORM 5 PCT, 1W SINGER PART NO. 151-1004-132J	GB1325	01121	1
A4R15	SAME AS A3R7			
A4R16	RESISTOR.FIXED.COMP., 220 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-221J	CB2215	01121	1
A4R17	SAME AS A4R4			
A4R18	RESISTOR.FIXED.COMP., 510K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-514J	CB5145	01121	1
A4R19	RESISTOR.FIXED.COMP., 22 OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-220J	CB2205	01121	1
A4R20	SAME AS R7			
A4R21	RESISTOR.FIXED.COMP., 12K OHMS,PORM 5 PCT, 1/4 SINGER PART NO. 151-1002-123J	CB1235	01121	1
A4R22 AND R23	SAME AS A4R4			
A5	LADDER AND BUFFER AMPLIFIER	103-1713-001	16665	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A5C1	SAME AS A1A1C1			
A5C2	SAME AS A3C7			
A5C3	SAME AS A3C4			
A5MC1 THRU MC3	INTEGRATED CIRCUIT,INVERTER SINGER PART NO. 556147-093	MC889P	04713	1
A5MC4	SAME AS A3MC1			
A5Q1	SAME AS A1A1Q3			
A5R1 THRU R17	RESISTOR,FIXED,FILM, 10K OHMS,PORM 1 PCT, 1/2W SINGER PART NO. 151-2012-A1002F	M1/2E10KOHMPORM1PCT	12126	1
A5R18 THRU R32	RESISTOR,FIXED,FILM, 5K OHMS,PORM 1 PCT,1/2W SINGER PART NO. 151-2012-A5001F	M1/2E5CCOOHMPORM1PCT	12126	1
A5R33	SAME AS A3R15			
A5R34	SAME AS A1A1R7			
A5R35	SAME AS A1A1R19			
A5R36	RESISTOR.FIXED.COMP., 2.7K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-272J	CB2725	01121	1
A5R37	RESISTOR,FIXED,FILM, 1740 OHMS,PORM 1 PCT, 1/2W SINGER PART NO. 151-2012-1741F	M1/2E1740OHMPORM1PCT	12126	1
A6	8 STAGE F/B COUNTER	103-1709-001	16665	1
A6C1	CAPACITOR,FIXED,ELECTROLYTIC, 100 UF,PLUS 75 MINUS 10 PCT,6V SINGER PART NO. 15C-5001-101BS	30D1C7GC06CC4	56289	1
A6MC1 THRU MC8	INTEGRATED CIRCUIT, INPUT GATE SINGER PART NO. 556147-095	MC892P	04713	1
A6MC9 THRU MC12	INTEGRATED CIRCUIT,FLIP-FLOP SINGER PART NO. 556147-094	MC890P	04713	1
A7	8 STAGE F/B COUNTER ALL PARTS LISTED IN THIS ASSY ARE IDENTICAL TO ITEMS LISTED IN ASSY A6	103-1709-001	16665	1
A8	CLOCK AND GATING ASSY	103-1711-001	16665	1
A8C1	SAME AS A6C1			
A8C2	CAPACITOR,FIXED,CERAMIC, 0.01 UF,PORM 20 PCT, 500V SINGER PART NO. 556060-012	5GAB-S10	56289	1
A8C3	CAPACITOR,FIXED,CERAMIC, 0.1UF PORM 20PCT, 25V SINGER PART NO. 556120-162	5C023104X025083	56289	1
A8MC1	INTEGRATED CIRCUIT, BUFFER SINGER PART NO. 556147-092	MC888P	04713	1
A8MC2	SAME AS A6MC1			
A8MC3	INTEGRATED CIRCUIT,INPUT GATE SINGER PART NO. 556147-091	MC825P	04713	1
A8MC4	SAME AS A8MC1			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A8C1 THRU C4	SAME AS A1A1C3			
A8C5	SAME AS A1A1C7			
A8Q6	TRANSISTOR SINGER PART NO. 556147-197	2N487C	04713	1
A8R1 AND R2	RESISTOR,FIXED,COMP., 2K OHMS,PERM 5 PCT, 1/4W SINGER PART NO. 151-1002-202J	CB2025	01121	1
A8R3 THRU R5	SAME AS A1A1R11			
A8R6	SAME AS A2R11			
A8R7	SAME AS A2R7			
A8R8	SAME AS R7			
A8R9	SAME AS A4R16			
A8R10	RESISTOR,FIXED,COMP., 20K OHMS,PERM 5 PCT, 1/4W SINGER PART NO. 151-1002-203J	CB2035	01121	1
A8R11	SAME AS A4R4			
A8R12 AND R13	SAME AS A4R11			
A9	15 VOLT POWER SUPPLY	103-17C2CC1	16665	1
A9CR1 AND CR2	SAME AS A4CR3			
A9CR3	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556147-122	1N821	04713	1
A9CR4	SAME AS A3CR5			
A9C1	CAPACITOR,FIXED,ELECTROLYTIC, 500 UF,PLUS 150,MINUS 10 PCT,25V SINGER PART NO.556146-017	BR5C0-25	93790	1
A9C2	CAPACITOR,FIXED,MICA, 200PF, PERM 5 PCT, 500V SINGER PART NO. 15C-2002-201EJC	DM15E201JC500WV4CR	72136	1
A9C1 THRU C3	SAME AS A1A1C3			
A9Q4	TRANSISTOR SINGER PART NO. 556147-123	40326	86684	1
A9C5	SAME AS A1A1C3			
A9R1	SAME AS A2R9			
A9R2	RESISTOR,FIXED,FILM, 1150 OHMS,PERM 1 PCT, 1/2W SINGER PART NO. 151-2012-A1151F	M1/2E1150OHMPERM1PCT	12126	1
A9R3	RESISTOR,FIXED,FILM, 28.7K OHMS,PERM 1 PCT, 1/2W SINGER PART NO. 151-2012-A2872F	M1/2E28.7KPERM1PCT	12126	1
A9R4	RESISTOR,FIXED,FILM, 40.2K OHMS,PERM 1 PCT, 1/2W SINGER PART NO. 151-2012-A4022F	M1/2E40.2PERM1PCT	12126	1
A9R5	RESISTOR,FIXED,COMP., 2.4K OHMS,PERM 5 PCT, 1/4W SINGER PART NO. 151-1002-242J	CB2425	01121	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A9R6	RESISTOR,FIXED,FILM, 4.12K OHMS,PORM 1 PCT, 1/2W SINGER PART NO. 151-2012-A4121F	M1/2E4120OHMPORM1PCT	12126	1
A9R7	RESISTOR,VARIABLE, 500 OHMS, .75 W SINGER PART NO. 556147-132	77P-R500	73138	1
A9R8	RESISTOR,FIXED,FILM, 2.8K OHMS,PORM 1 PCT, 1/2W SINGER PART NO. 151-2012-A2871F	M1/2E2870OHMPORM1PCT	12126	1
A9R9	RESISTOR,FIXED,COMP., 5.1 OHMS,PORM 5 PCT, 1/2W SINGER PART NO. 151-1003-5R1J	EB5R15	01121	1
A10	-15 VOLT POWER SUPPLY ALL PARTS LISTED IN THIS ASSY ARE IDENTICAL TO ITEMS LISTED IN ASSY A9.	103-1702-001	16665	1
A11	LOW VOLTAGE POWER SUPPLY	103-1703-001	16665	1
A11CR1	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556166-039	1N823A	INSTD	1
A11CR2 THRU CR7	SAME AS CR1			
A11C1	SAME AS A3C4			
A11C2	SAME AS A3C7			
A11C3	SAME AS A3C4			
A11C4	SAME AS C5			
A11MC1	SAME AS A3MC1			
A11Q1 AND Q2	SAME AS A9Q4			
A11Q3 AND Q4	SAME AS A1A1Q3			
A11R1	RESISTOR,FIXED,FILM, 3.92K OHMS,PORM 1 PCT 1/2W, SINGER PART NO. 151-2012-A3921F	M1/2E3920OHMPORM1PCT	12126	1
A11R2	RESISTOR,FIXED,FILM, 6.49K OHMS,PORM 1 PCT, 1/2W SINGER PART NO. 151-2012-A6491F	M1/2E6490OHMPORM1PCT	12126	1
A11R3	RESISTOR,FIXED,FILM, 1.5K OHMS,PORM 1 PCT, 1/2W SINGER PART NO. 151-2012-A1501F	M1/2E1500OHMPORM1PCT	12126	1
A11R4	RESISTOR,FIXED,FILM, 15K OHMS,PORM 1 PCT, 1/2W SINGER PART NO. 151-2012-A1502F	M1/2E15KOHMPORM1PCT	12126	1
A11R5	RESISTOR,FIXED,FILM, 3.01K OHMS,PORM 1 PCT, 1/2W SINGER PART NO. 151-2012-A3011F	M1/2E3010OHMPORM1PCT	12126	1
A11R6	RESISTOR,FIXED,COMP., 47K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-473J	CB4735	01121	1
A11R7	RESISTOR,FIXED,COMP., 11K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-113J	CB1135	01121	1
A11R8	SAME AS A3R4			
A11R9	SAME AS A3R15			
A11R10	RESISTOR,FIXED,FILM 1.5K OHMS PORM 1PCT, 1/2W SINGER PART NO. 151-2012-A1501F	M1/2E1.5KOHMPORM1PCT	12126	1

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qty
A12	HIGH VOLTAGE AMPLIFIER	103-1712-001	16665	1
A12CR1	SAME AS CR2			
A12C1C SAME		3		
A12C2	CAPACITOR,FIXED,MYLAR, 0.047 UF,PORM 10 PCT, 1600V SINGER PART NO. 556147-144	PKM16S47	93790	1
A12C3	CAPACITOR,FIXED,ELECTROLYTIC, 5 UF,PLUS 75 MINUS 10 PCT,50V SINGER PART NO. 150-5001-5ROFS	30D505G050BB4	56289	1
A12C4	CAPACITOR,FIXED,DIPPED MICA, 160PF, PORM 5PCT, 500V SINGER PART NO. 150-2002-161EJO	DM15E161J0500WV4CR	72136	1
A12Q1 THRU Q7	TRANSISTOR SINGER PART NO. 556147-124	40327	86684	1
A12Q8	SAME AS A1A1Q7			
A12Q9	SAME AS A1A1Q3			
A12R1	SAME AS A4R7			
A12R2	SAME AS A1A1R7			
A12R3	SAME AS R7			
A12R4	SAME AS A1A1R1			
A12R5 THRU R9	RESISTOR,FIXED,FILM, 200K OHMS,PORM 1 PCT, 1/2W SINGER PART NO. 151-2012-A2003F	M1/2E200KDHMPORM1PCT	12126	1
A12R10 THRU R16	RESISTOR,FIXED,COMP., 130K OHMS PORM 5 PCT, 1W SINGER PART NO. 151-1004-134J	GB1345	01121	2
A12R17	SAME AS A2R7			
A12R18	SAME AS A8R10			
A12R19	SAME AS A1A1R7			
A12R20	SAME AS A1A1R1			
A12R21	RESISTOR,FIXED,COMP., 3K OHMS,PORM 5 PCT, 1/4W SINGER PART NO. 151-1002-302J	CB3025	01121	1
A12R22	SAME AS A11R6			
A13	HIGH VOLTAGE AMPLIFIER	103-1707-001	16665	1
A13CR1	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556166-037	IN969B	01295	1
A13CR2 THRU CR5	SEMICONDUCTOR DEVICE,DIODE SINGER PART NO. 556118-164	HV-20B	13327	1
A13Q1 THRU Q7	SAME AS A12Q1			
A13R1 THRU R7	RESISTOR,FIXED,COMP., 68K OHMS,PORM 5 PCT,2W SINGER PART NO. 151-1005-683J	HB6835	01121	1
A13R8 AND R9	SAME AS A8R1			

TABLE 6-2. PARTS LIST

Ref Symbol	Description	Manufacturer's Part Number	Mfr's Code	Maint Qtv
A14	15 PIN SERVICE EXTENDER BOARD ASSY	103-1714-001	16665	1